The Dock and Harbour Authority

No. 219. Vol. XIX. Edited by BRYSSON CUNNINGHAM, D.Sc., B.E., F.R.S.E., M.Inst.C.E. JANUARY, 1939

Editorial Comments

Retrospect and Prospect.

With the advent of each succeeding new year the human mind naturally, indeed almost automatically, tends to cast a backward look at the happenings of the preceding twelve months. When this review takes on a personal aspect and develops into a process of critical introspection, it leads, in the majority of cases, to the formation of what are familiarly known as "New Year Resolutions," which, however salutary and beneficial in intention, after a short interval, often measured in days, become more honoured in the breach than in the observance. We have no wish to take part in a moral comedy of this kind and our reason for making a short retrospect is simply because we feel it may be interesting and perhaps useful, to touch upon a few of the events of 1938 which have closely affected port administration.

Undoubtedly, the most outstanding incident was the nightmare experience of the last week in September when the nation was brought to the verge of an abysmal precipice and port authorities were faced with a situation of extreme peril. Despite measures taken during the preceding months, in many cases deficiencies in A.R.P. were only too obvious at ports and harbours, as indeed everywhere. What would have happened if war had actually broken out is a speculation which even now excites a sensation of dismay. The situation, no doubt, would have been saved in some fashion, in accordance with the time-honoured British practice of "muddling through," but the cost would have been heavy. We need not dwell on the matter further beyond expressing the hope that the lesson has been learned, and that there will be no half measures tolerated for the protection against aerial attack of shipping and commerce in the ports of the British Isles. In this connection, we venture to reiterate the need for effective inland waterway transport to supplement the road and rail services in the distribution of imported foodstuffs and raw materials. As has been repeatedly urged in these columns, there is abundant scope in this direction for the revival and modernisation of neglected canal routes.

A much more pleasant incident, attracting warm congratulations from all quarters, was the celebration of the centenary of the Southampton Docks on October 12th. This was the fitting culmination of a long series of port extension works enterprisingly begun and indefatigably carried out by the Southern Railway Company, who have been instrumental in raising Southampton from a position of relative insignificance to the proud standing of the premier overseas passenger port of the country. The accomplishment of the construction of the long length of quayage in the River Test for ocean liners is too well known for further particularisation, and the new King George V. Graving Dock is a monumental contribution to ship-repairing facilities at a British port.

At London, the port authority have actively pursued a programme of dock re-modelling which is costing no less than twelve million sterling and the coming year should see the completion of the work at the Royal Victoria Dock.

It would take too long, however, and there is insufficient space to allude to all the improvements which have been carried out at British ports. It is a pleasure to note that many development works are still in progress or in contemplation, and the good wishes of those who are interested in the welfare of sea-borne commerce will go out to the promoters of all measures for its safe and commodious accommodation in ports and harbours. We join with the Management of this Journal in wishing our readers a Very Happy and Prosperous New Year.

A Noted Welsh Port.

Swansea, the subject of our leading article this month, occupies an outlying position at the foot of the Gower Peninsula in Glamorganshire, among the cluster of ports located along the coastline of the Severn Estuary and known in common parlance as the Bristol Channel Ports. Until comparatively recently, like Bristol on the opposite shore, Swansea maintained a detached individuality, aloof from and independent of the other ports in the vicinity which were under railway management. This was because of its autonomous administration under a Harbour Trust. Apart therefrom, the inception of the South Dock was due to a private company, but later this company's undertaking was absorbed in the Harbour Trust. The amalgamation of the railways of Great Britain in 1921, led to the inclusion of Swansea within the Great Western system and it is so administered at the present day.

Like the neighbouring Port of Cardiff, Swansea is a place of respectable historical antiquity, owing its origin, so far as can be gathered from records, to the erection in 1099 of a castle (some remains of which are still in existence) at the mouth of the River Tawe, by Henry Beauchamp, Earl of Warwick, who garrisoned it with English and Flemish settlers. This fortress appears to have had a lively and eventful history during the next two centuries, being frequently assaulted and finally burnt down in 1200 by Llewellyn ap Griffith, last Prince of North Wales A similar disastrous fate overtook it during the rebellion of Owen Glendower in the reign of Henry IV. (1399-1422). In the Civil War of the 17th Century, the town changed hands between the rival Royalists and Parliamentarians, but eventually the phœnix-like castle was dismantled by the former party, when Oliver Cromwell was made "Lord of Swansea."

In recent times, Swansea has been a flourishing port with an extensive trade of a very varied description, embracing coal, patent fuel, copper, silver, lead and tin. It has been particularly notable for its export of tinplates, the manufacture of which within a dozen miles of the port has been so considerable as to be estimated at three-fourths of the whole output of the kingdom.

Naturally, the economic landslide of the last few years has had its effect on the fortunes of Swansea and although not definitely scheduled as a "Special Area," the prevailing depression is such as to produce an agitation in favour of its inclusion with adjacent areas in a single economic unit for the whole of South Wales.

The future of Swansea, however, is not unhopeful. It has wide interests and, given a recovery of trade generally, it should benefit from the natural advantages which it enjoys—not least that it does not lie in too close proximity to objectives of aerial attack, and that its situation at the foot of lofty hills confers upon it, to some extent, a natural impregnability.

The Pneumatic Discharge of Grain Cargoes.

The floating pneumatic elevator is a common object in the docks and rivers of most commercial ports, and it is desirable that those who have occasion to make frequent use of the appliance should become acquainted with the important part played by an English engineer in the application of the principle of air suction to grain discharge. We are indebted to Dr. Carl Mueller, of Brunswick, for his esteemed permission to reproduce in this and succeeding issues, from the "Jahrbuch der Hafenbautechnischen Gesellschaft," his detailed and interesting paper on the Development of the Floating Pneumatic Grain

Editorial Comments—continued

Elevator, which shows how English and German engineers have competed and co-operated in the evolution of one of the most effective port discharging appliances of the present day. Great credit is due to the late Mr. F. E. Duckham, of the Millwall Docks Company, in conjunction with the late Mr. F. S. Tuckett, of the East Ferry Road Engineering Works, for the enterprising and courageous part which he played in adapting the results of his investigations to practical ends, and also to the German engineers who followed in the path of his researches and produced improvements of no less value. Another English engineer should be mentioned in this connection—the late Mr. A. H. Mitchell—who, during the period of his service with the Port of London Authority, introduced with great success a number of modifications in the design. The fleet of elevators in the service of the Port of London is one of the most complete and effective to be found at any port in the world.

Grain Transport.

Apart from the particular method of handling dealt with in Dr. Mueller's article, the whole subject of grain transport from overseas is bound to exert a profound influence on the policy of port authorities in this country, seeing that, owing to the inadequacy of the national wheat harvest, it is imperative to import large quantities of grain from abroad, principally from the Argentine, Canada, Australia, and from India. Accordingly, we are glad to be able to reproduce in this and succeeding issues, a large section of the report of a lecture by Mr. Cecil Bentham on Transporting the Grain Harvests of the World, in which he has described, with a wealth of statistical detail, the various sources from which supplies of grain are forthcoming, and the process of distribution of consignments to the several countries, of which Great Britain is one of the leading recipients. Mr. Bentham points out that the inhabitants of the British Isles depend for their existence upon adequate supplies of grain from overseas. There is a consequent obligation on port authorities to provide the most effective and economical means of handling the grain at the quayside, so as to reduce as far as possible the cost of transport. The question of cost is an important consideration, not only as regards the charges for delivery at the port of arrival, but also as regards the internal rail and road service to the interior, and Mr. Bentham shows that the relatively high cost per ton for transporting grain in this country, is one of the primary economic reasons underlying the present tendency for new mills to be built at deep-water berths at British ports.

Port Emergency Works.

The activities of A.R.P. at most of the larger ports are well in evidence, and Port Emergency Committees appointed by the various authorities have been acting with commendable promptitude and initiative. But the field of action is very wide, and it is to be feared that, in many cases of the smaller ports, local resources will be inadequate to meet the outlay which will be necessary, if completely effective steps are to be taken to protect shipping and port staffs from aerial attack. Furthermore, there is possibility of ill-advised and unwarranted expenditure, unless the work is properly organised. It is satisfactory, accordingly, to see in the press a statement, on what seems to be reliable authority, that the Government will announce in the near future a co-ordinated system of protective measures, and that a considerable part of the cost of this will be met from the public funds. It is pointed out that ports devoted in times of peace to purely commercial functions will, under war-time conditions, become bases for local defence and patrol craft. It will, accordingly, be necessary for them to be prepared to handle an increased amount of traffic, which will probably be accentuated on the Western seaboard by the visits of a number of vessels diverted from Eastern routes.

The decline in coastwise traffic during recent years has had the effect of checking expenditure on the maintenance and upkeep of some of the smaller ports, and in cases where these are likely to be of strategical importance, it will be necessary to put in hand, without delay, measures for bringing them up to a definite standard of utility and service. The difficulty will be to devise a scheme of operations which can be carried out within a reasonable period. Time is of vital importance, and port works are notoriously liable to protraction owing to difficulties of weather and exposure.

The outbreak of hostilities, if and when it happens, will be so sudden that ports must be ready for immediate action.

Hull Dock Extension Representations.

An effective and conclusive rejoinder has been made by Major W. H. Carver, M.P., to the demand put forward by the Hull Chamber of Commerce and Shipping for an increase in the dock accommodation at the Port of Kingston-upon-Hull, or Hull, as it is more popularly known. The docks at Hull are the property of the London and North Eastern Railway Company, and Major Carver, who is a director of the Company, informed the Chamber at their recent annual meeting that it was obvious, from the weekly traffic returns, that there was no money coming in which would be available for improvements. There was, he stated, not the slightest chance at the present time of an extension of the King George Dock which had been advocated by the Chamber.

There will be a certain amount of sympathy with the attitude of the railway company, for it is well known that British railways are suffering in a very marked degree from the competition of road traffic, and their receipts have declined to an alarming extent. Latterly, they have been agitating for "a square deal," as they call it, which is the subject of investigation by the Ministry of Transport. This would give them more freedom in fixing rate charges. Incidentally, it has provoked a demand for consideration of the interests of canal transport.

No doubt there is room, as elsewhere, for enlarged accommodation at the Hull docks, though it has to be remembered that the London and North Eastern Railway Company have carried out, during the past year, a number of improvements for the timber trade and the fishing industry. Major Carver went so far as to suggest that if the trading community felt the need for further improvements they "should support the request"—financially, we presume. But this suggestion is hardly likely to take tangible shape, since dock development schemes, as a rule, require heavy capital subsidies, which it may be beyond the capacity of a local trade organisation to provide.

The Tunnelling of the Thames.

The increase in the number of tunnels under the Thames is an obvious outcome of the needs of modern road transport. The demand for an arterial roadway connecting East Anglia with the South Eastern counties is being met by the construction of the tunnel between Dartford and Purfleet, the bore of which for the pilot heading has just been completed. Following this, the London County Council have undertaken the construction, at a cost of nearly two millions, of a duplicate of the Blackwall Tunnel in order to relieve the congestion in the existing tunnel. This new tunnel will take all South-bound traffic, leaving the old tunnel to deal with the North-bound traffic. Auxiliary work in the provision of suitable approaches, including the demolition of property, will involve the outlay of another million.

Apart from the enormous cost involved, the construction of tunnels at river entrances and under the approach channels to ports, as pointed out on previous occasions, has the serious disadvantage of limiting the extent to which such channels may be deepened to accord with developments in the loaded draught of shipping; but, in the case of the Dartford-Purfleet Tunnel, ample allowance has been made at the instance of the Port of London Authority, while in the case of the Blackwall Tunnel the standard of depth has already been irrevocably fixed.

Continental Port Competition.

Recent returns of the tonnage of shipping visiting the four great commercial ports of North Western Europe, in comparison with the figures of six years ago, show a striking increase as regards Rotterdam, a less notable increase for Antwerp and Bremen and a trifling increase at Hamburg.

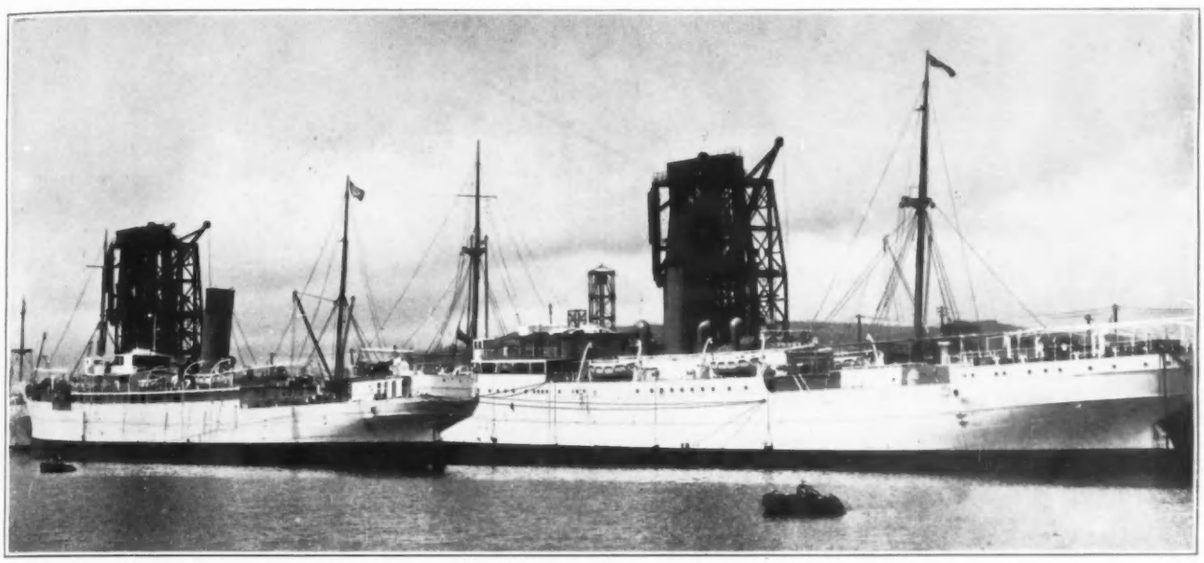
This has been the subject of comment and explanation in an article on "Hamburg and Competition of Seaports," published in a recent issue of the Bulletin of the "Hamburg World's Economic Archives." The writer argues that Hamburg is the terminus and starting point of the largest ocean traffic routes of the world; that, in the statistical returns the ships calling at Hamburg and leaving it again, appear but once—provided they do not undertake an intermediate voyage for the unloading of a cargo remainder or to take in a part cargo—whereas, at the competing harbours on the same route, they are often statistically included both on entry from overseas and on their re-entry from the terminus and starting point of the voyage, i.e., the continuation of the voyage of the ship to her last port of unloading is statistically registered as an independent voyage. Admitting that this is not true for all ships, the extent of ocean-going traffic as gauged from the returns may, however, it is contended, lead to erroneous conclusions, if the number and size of ships entering the harbours do not differ considerably from one another, or if in the course of a few years they are subject to heavy fluctuations.

The foregoing plea for the Port of Hamburg instances the desire (a perfectly natural one, shared by all port authorities) to place the trade of each particular port in its most favourable light, and it also indicates, in some measure, the weakness of standards of comparison adopted for measuring the trading activities of ports. The number and tonnage of visiting vessels, the weight and value of goods imported and exported are alike used for standards of prosperity, and in no case can it be maintained that the method is free from objection, and gives a fair and unbiased verdict. Whether any really unassailable criterion can be devised is open to question, and ports, no doubt, will continue to make use of the measuring rod which is best adapted to give the superiority they wish to claim.

The Port of Swansea

A Notable Bristol Channel Port

By W. J. THOMAS, Chief Docks Manager, Gt. Western Railway



Vessels at Hoists, King's Dock, Swansea

SWANSEA is the westernmost of the major ports on the South Wales seaboard owned by the Great Western Railway Company, and is the nearest to the Atlantic Ocean; it is situate in the heart of a great industrial area, and as a result of steady development ranks to-day as one of the great seaports of the country.

Some description of port existed at Swansea as far back as the beginning of the 14th Century, but it was not until the 17th Century that quays along the River Tawe for the loading of small vessels with coal, and two small stone piers were constructed. Trade expanded, and in 1768 it is recorded that 694 vessels entered Swansea Harbour, which number increased to 1,667 in the year 1790. This expanding trade forced upon the inhabitants of Swansea the necessity for improving the port, which was then merely a tidal harbour. The result was the passing of the first Swansea Harbour Act in 1791, under which an authority composed of trustees representative of the several interests of the port was created for the purpose of "repairing, enlarging and preserving the Harbour of Swansea."

The North Dock

Various schemes were considered for the construction of a floating harbour to enable vessels to load and unload under all conditions of the tide, but it was not until 1836 that an Act was past authorising the trustees to float the Town Reach and make a new cut through which the River Tawe could be diverted.

This Float, or the North Dock as it was afterwards known, was opened for traffic in January, 1852, and had a water area of 11½ acres: a basin was subsequently added in 1861. This dock was one of the first in the country to employ hydraulic power for working the lock gates and sluices.

It may be remarked here that the North Dock remained in use for over 70 years, being eventually closed in 1930 by reason of its obsolescence. The basin, however, is still actively used in connection with a large grain and flour trade.

The South Dock

In 1847 Parliamentary powers were obtained by an independent concern, known as the Swansea Dock Company, for the construction of a new dock on the West side of the harbour and to the South of the town. The financial resources of this Company became exhausted before the dock was completed and the works were afterwards taken over and finished by the Swansea Harbour Trustees under their Act of 1857. This dock, known as the South Dock, was opened for traffic on the 23rd September, 1859.

The opening of the North and South Docks gave a considerable fillip to the port's trade, and facilities were taxed to the utmost. Additional accommodation became an urgent necessity, and the necessary authority was obtained under the Swansea Harbour Act of 1874. The new dock was constructed on the East side of the River Tawe and was formally opened in October, 1881, by the Prince of Wales, afterwards King Edward VII., as the Prince of Wales' Dock. An extension to this dock was added in 1898.

The growth of trade was such, however, that the trustees were compelled to consider the provision of a still larger deep water dock. The configuration of the land around the existing docks did not admit of any useful extension either eastward or westward and in order to find a site for the new dock an area of 400 acres on the foreshore was reclaimed from the sea, within which the new dock works were carried out. Very commendable foresight was shown by the trustees in reclaiming a sufficient area for the construction of two docks of a size which, it was considered, would, with the accommodation already in existence, be sufficient for the port's needs for very many years ahead. The trustees' foresight has since been justified by the passage of time.

King's and Queen's Docks

The necessary powers for the new works were obtained under an Act of 1901, and the new King's Dock, as it was known, was formally opened for traffic in November, 1909.

The second new dock was for many years utilised as a timber float, but was eventually opened as the Queen's Dock by Queen Mary in 1920. This dock is almost entirely reserved for the business of the Anglo-Iranian Oil Co., Ltd., who import annually over half-a-million tons of crude oil from Iran and Iraq for refining at their great Llandarcy Refineries, about 4 miles out of Swansea. The refined products are also shipped from the Queen's Dock to all parts of the world.

During the years of the Great War the shrinkage in revenue led to the Swansea Harbour Trustees becoming financially embarrassed, with the result that they were unable to meet the fixed interest due to their mortgage and stock holders, and this led to the appointment of Receivers. Eventually the undertaking was merged into the system of the Great Western Railway Company as from the 1st July, 1923.

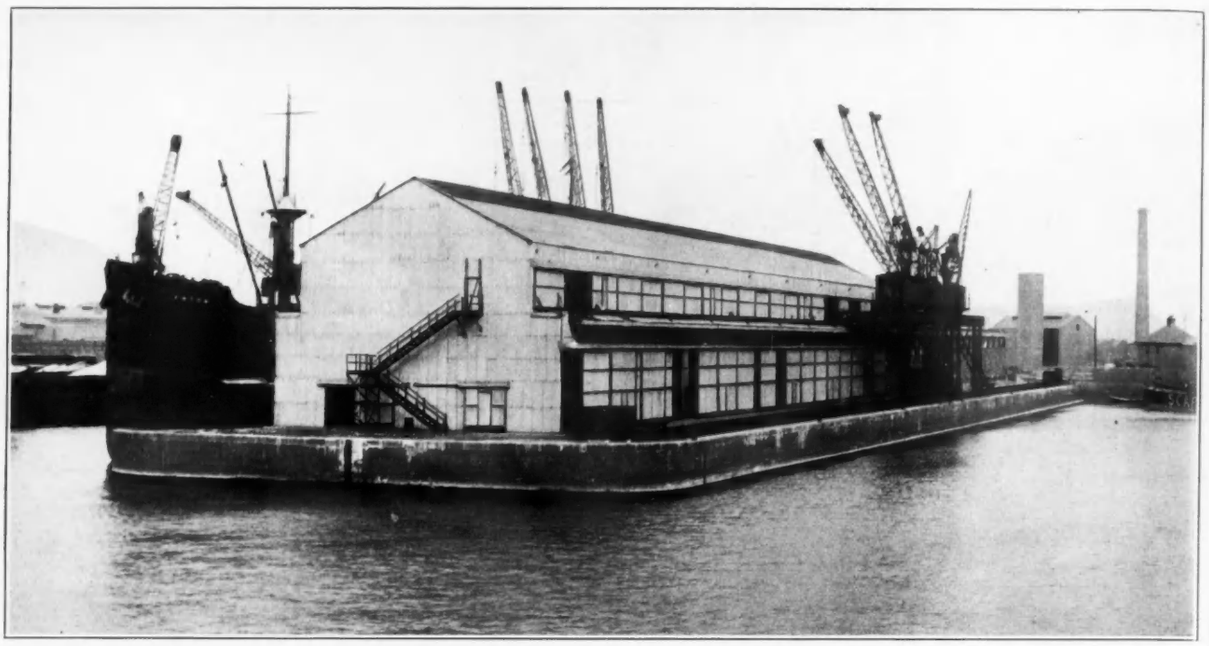
The Port of Swansea to-day consists of five docks, viz.: the King's, Queen's, Prince of Wales and South Docks and the North Dock Basin, with a total water area of 269 acres and 32,536-ft. of quayage. The docks are surrounded and served by 117 miles of railway connected with the Main Line of the Great Western Railway and also with the Midland and North-Western sections of the London, Midland and Scottish Railway, whilst siding accommodation has been provided for over 12,000 wagons.

The following summary gives particulars of each dock, viz.:—

Dock	Area Acres	Normal depth of water in dock Feet	Quayage Feet
King's	70	30¼	13,971
Queen's	150	30¼	3,650
Prince of Wales	28	24¼	7,164
South and Basin	18¼	21	6,310
North Basin	2¼	Tidal	1,441

Entrance from sea to the King's, Queen's and Prince of Wales Docks is obtained through the King's Dock Lock, which is 875-ft.

Port of Swansea—continued



Transit Shed, The Mole, King's Dock

long by 90-ft. wide, provided with three pairs of steel gates operated by direct acting hydraulic rams which divide the lock into two compartments of 500-ft. and 375-ft. respectively. Small-sized vessels may thus be passed through without utilising the whole length of the lock. The depth of water over the outer cill of the lock is 40-ft. at H.W.O.S.T. and 32-ft. 8-in. at H.W.O.N.T.; at L.W.O.S.T. the depth is 12-ft. and at L.W.O.N.T. 19-ft. 9-in. The passageway between the King's and Prince of Wales' Docks is 70-ft. wide, and that between the King's and Queen's Docks 100-ft. wide.

The water level in these three docks is maintained by two powerful electrically-operated feed pumps each of 48-in. diameter, which inject water into the Prince of Wales' Dock at the rate of 50,000 gallons per pump per minute. These pumps enable the head of the water in the docks to be maintained at a constant level and counteract the loss which would otherwise occur as a result of locking operations during neap tidal periods.

The South Dock is served by an entrance lock 370-ft. long by 58-ft. wide, with a depth of water on the outer cill of 34-ft. at H.W.O.S.T. and 26½-ft. at H.W.O.N.T. This dock is also equipped with electric impounding pumps.

The entrance to the North Basin is 58-ft. wide with 32-ft. of water on the cill at H.W.O.S.T. and 24½-ft. at H.W.O.N.T.

Cargo Handling Appliances

No expense has been spared by the Great Western Railway Company in equipping the docks at Swansea with the most up-to-date appliances for the handling of cargo. Fifteen coal hoists have been installed by the Great Western Railway Company and four by the London, Midland and Scottish Railway Company, whilst the latter Company has also erected an electric coaling belt conveyor at the Prince of Wales' Dock. The whole of the coal hoists are operated by hydraulic machinery and 17 of these are capable of shipping coal contained in 20-ton wagons.

The coal hoists at the King's Dock are operated on the high level system, under which loaded wagons are run by gravitation on to the hoist cradle and the empty trucks returned—also by gravitation—to the storage sidings, from whence they are drawn out by locomotives for return to collieries.

Under this system of shipment no coal trucks, loaded or light, descend to the quay level, thus leaving the railway lines and roads around the dock free of obstruction.

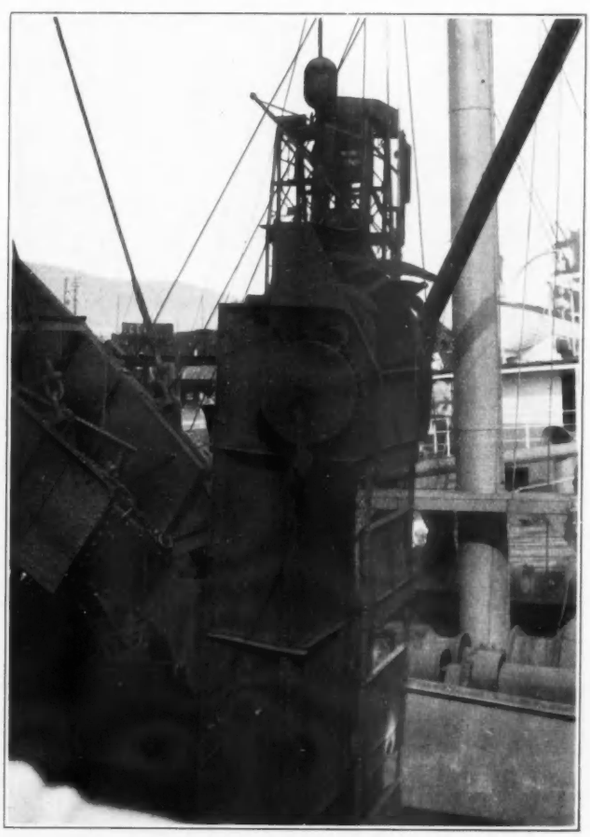
At the Prince of Wales Dock, however the loaded wagons are passed on to the hoists at quay level, the empties being run away by gravitation on the high level.

The system at the South Dock, however, is, owing to restriction of room, somewhat different, wagons having to be run, on the high level, at right angles to the tipping appliances and passed on to the hoist cradles by means of turntables. The empties are dealt with in similar manner.

The majority of the coal hoists are fitted with appliances known as Hancock Anti-Breakage Escalators; this type of escalator consists of a number of trays revolving on an endless belt, and, when fixed to the mouth of the coal hoist shute, coal passes on to each tray and is deposited gently into the steamer's hold by gravity. This method of loading obviates the breakage of coal, and ensures that cargo is placed aboard vessels in the best possible condition.

Three of the coal hoists are each fitted with a " Norfolk " Spade, a mechanical contrivance utilised for the removal of damp duff and other " sticky " coals, which adhere to the sides and floors of wagons after the vehicles have been tipped. The " Norfolk " Digger essentially is a large metal spade adjustable to the width of the wagons being tipped, which, in operation, scoops out the coals remaining in the vehicles and so obviates the laborious manual operation which has to be performed at hoists not so equipped.

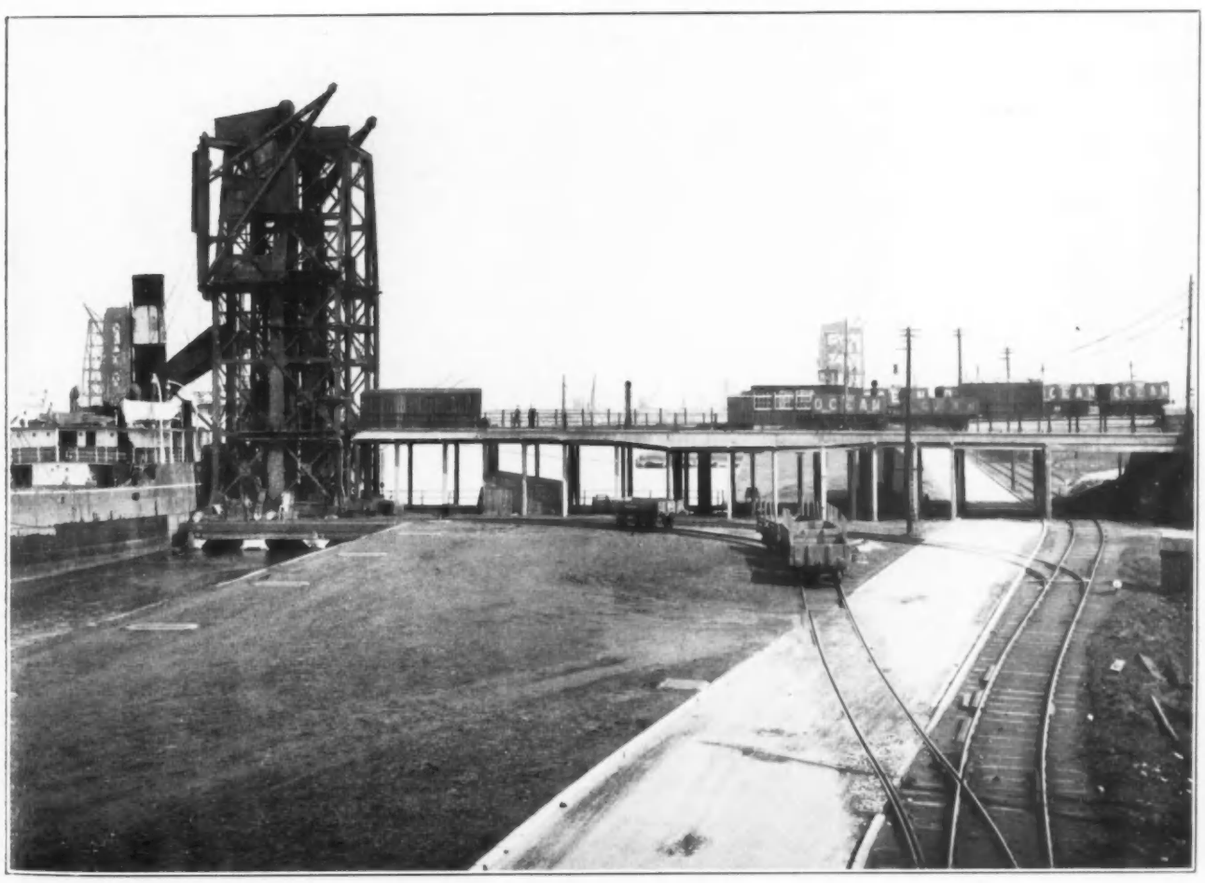
At the L.M.S. Company's Coaling Belt Conveyor at the Prince of Wales Dock coal is tipped from wagons into a concrete bin by means of a " tippler." It is then passed from the bin on to an



Shipping Coal through an Anti-breakage Appliance, Swansea

Port of Swansea

King's Dock Lock, Swansea



Coal Hoists, King's Dock, Swansea

Port of Swansea—continued

Prince of Wales Dock, Swansea

endless belt which, in turn, passes it on to an anti-breakage escalator fitted with a swivelling mouth at its lower end, thus enabling coals to be loaded in the required direction in the vessel's hold.

Sidings

The major portion of the coal shipped at Swansea arrives at the port by the Great Western line which approaches from the East. To deal with this enormous volume of coal and other freight traffic the railway approaches at this point have been entirely remodelled and extensive reception, riddling and storage sidings with a new hump yard have been laid down. Trains are drawn in to the reception sidings and run over the hump into the riddling sidings according to the shipment order. From the riddling sidings they are passed into the vast groups of storage sidings, from whence they are taken direct to the coal hoists or other points, as the case may be.

Coal Hoists, South Dock, Swansea

Empties are also dealt with in a similar manner, being taken out of the dock area and passed over a hump into despatch sidings according to destination order.

This vast system, which affords siding accommodation for 5,190 wagons, permits of the utmost fluidity of traffic, and ensures its swift and efficient handling.

Existing cranage facilities are extensive, the docks being equipped in all with 101 cranes, 64 of which are operated by hydraulic power and 37 by electricity. The appliances are of varying lifting capacities, ranging from 1½ tons to 70 tons, whilst in addition, the Great Western Railway Company have a 125-ton floating crane available for use. The majority of the electric cranes are of the quick-acting level-luffing type, with a lifting capacity of 3 tons, these having been found to be particularly suitable for the class of general cargo exported from Swansea.

For the rapid discharge of bulk cargoes, an import wharf at the King's Dock is equipped with a battery of nine 5-ton hydraulic luffing jib cranes fitted with 3-ton grabs.

Special facilities are also available for the discharge of scrap cargoes by the provision of new type grabs, and these are being augmented as a result of the rapid growth of this class of traffic.

To prevent damage to boxes of tinplates and bundles of black steel sheets a special contrivance known as the Scott Grip is in use; this appliance consists of two steel legs with flanged feet which grip the heave of plates securely and so prevent boxes being broken and the edges of the plates being burred, as occurred in the days when chain slings were used. These machines are light and enable the wharf cranes to take their full loads.

At the North Basin a travelling grain elevator has been installed by Messrs. Weaver and Co., Ltd., with a capacity of 180 tons per hour.

Trade of the Port

The importance of the port may be gauged from the appended summary of imports and exports and the number of vessels, with their net registered tonnage, which entered Swansea during the years 1930 to 1937:—

Year	Imports	Exports	Total	No. of vessels which entered the Port	N.R.T
1930 ...	1,471,856	5,422,757	6,894,613	5,037	4,021,945
1931 ...	1,089,051	4,464,656	5,553,707	4,609	3,413,120
1932 ...	990,585	4,734,451	5,725,036	4,802	4,036,262
1933 ...	992,472	4,647,576	5,640,048	4,679	3,883,448
1934 ...	1,049,460	4,674,487	5,723,947	4,820	3,915,085
1935 ...	1,051,904	4,139,414	5,191,318	4,358	3,597,869
1936 ...	1,120,009	3,912,791	5,032,800	4,366	3,437,326
1937 ...	1,451,002	4,902,334	6,353,336	4,791	3,788,679

Port of Swansea—continued

Coal exports account for over three million tons per annum, practically 70% of which is anthracite, the principal countries to which this traffic is shipped being France, Canada and Italy.

Swansea, however, is not dependent on coal exports alone, as it has an extensive general cargo export trade, of which tinplates, terneplates, blackplates and galvanised sheets form the most important items. These products are manufactured mainly in the Swansea district, and are shipped from the port to all parts of the world.

Other export traffics handled are patent fuel briquettes, rails, tubes, steel sleepers, machinery, cement, refined oil, refined copper and nickel, nickel sulphate, general merchandise, etc.

On the import side items are varied and consist principally of crude oil, zinc concentrates, nickel matte, unrefined copper Manganese ore, tin ore, and tin ingots, pig iron, scrap, steel billets and pitprops, timber, grain, general merchandise and Canadian produce.

The valuable general cargo trade handled at the port necessitates adequate transit shed accommodation; twenty of such sheds have been provided with a total floor area of 816,572 sq. ft., and several of these are equipped internally with overhead electric gantries, electric mobile cranes and electric platform trolleys for the handling of cargo.

Fishery Trade

A valuable fishing trade has been built up at Swansea, approximately 10,000 tons of fish being landed yearly by Consolidated Fisheries, Ltd., who operate a large fleet of steam trawlers from the port. The business is carried on at the South Dock Basin, where a large market has been provided and an ice factory installed.

The varied nature of Swansea's trade has led to the establishment of an extensive list of general cargo liner services, the following lines making regular calls, viz.:—Alfred Holt, Nippon Yusen Kaisha, Federal, Hall, Ellerman City, Harrison, Clan, Anchor, Anchor-Brocklebank, Henderson, Bibby, Royal Mail, Pacific Steam Navigation, Holland-Amerika, Houlder, Donaldson, Bristol City, Johnston, Cunard-Ellerman, Ellerman-Wilson, Holland, Bristol Steam Navigation, MacAndrews, and many others.

These steamship lines between them maintain direct sailings between Swansea and practically every European country having a seaboard, as well as Turkey, Syria, Palestine, Egypt, North Africa, Sudan, Arabia, Persian Gulf, Kenya, Tanganyika, Portuguese East Africa, Natal, India, Ceylon, Burma, Straits Settlements, Netherlands, East Indies, Phillipine Islands, China, Japan, Australia, New Zealand, Panama, Brazil, Uruguay, Argentina, Falkland Islands, Chile, Peru, Colombia, and the Pacific and Atlantic Coast Ports of the United States and Canada.

Dry Docks

Dry dock accommodation is sufficient for all classes of vessels visiting Swansea, five dry docks being available, the largest of which is 560-ft. long, with an entrance of 75-ft. A repairing jetty 760-ft. long is also available in the Queen's Dock for vessels requiring repairs whilst afloat.

Legal Notes

(By our Legal Correspondent)

Harbour Dues on Cargo Boats used for Towing

Interest and importance attach to the recent decision of the Court of Appeal in the case of Great Yarmouth Port and Haven Commissioners v. F. T. Everard & Sons, Ltd. The case concerned the liability of shipowners for towage dues in circumstances which are now not unusual, but which, in the contention of the shipowners, were not contemplated when the Haven's schedule of tolls was drawn up.

The defendant company were owners of a number of cargo vessels which traded up the River Yare from the plaintiff's harbour to Norwich. Some of the boats were motor vessels and some were sailing vessels. Where vessels of both kinds were navigating the port and river at the same time and in the same direction, it was obviously more convenient and economical for the motor-ships to tow the sailing craft, and this was frequently done. In these circumstances dues were payable in respect of both tows and motor-ships as cargo vessels.

The Haven Commissioners, however, claimed that they were entitled to towage dues in addition to the dues for cargo boats. Such towage dues were payable under the schedule if a vessel were towed by a tug-boat into or out of the Haven, but in the present case the defendant shipowners contended that if they towed their own sailing vessels with their own motor-ships they were only liable for the dues on cargo boats and not at all for towage dues. Incidentally, they also claimed that if they were liable to pay the towage dues, they also had the right to commute them under another clause of the Schedule for a lump sum payment.

At first sight, the double imposition on the shipowners may seem a hardship. Cargo boats which have paid their dues as such, giving what might be termed "a friendly lift," may seem to be in a different category from tug-boats pursuing their normal activities. On the other hand, if this system of towing became general, exemption from towage dues might result in considerable loss of revenue to Harbour Authorities.

The three Lords Justices of the Court of Appeal appear to have viewed the matter in a practical light, and they unanimously confirmed the judgment of the Court of first instance in favour of the Port Commissioners. Lord Justice Slesser, in delivering judgment, said he thought the language of the Schedule was unambiguous, and that the Harbour Commissioners were given power to charge a vessel which was towing another vessel in or out a toll of 3s. 4d. a ton. With regard to the contention that Messrs. Everard were entitled to commute their liability by the payment of £10 for what had been called a "season ticket," Lord Justice Slesser thought that the right was limited to vessels primarily used for towing, or tugs, and did not extend to Messrs. Everard's vessels.

Leave to appeal to the House of Lords was refused, and it may now be taken as definitely established that in all cases of one vessel towing another in circumstances similar to those existing at Great Yarmouth, the Harbour Authority concerned is justified in levying towage dues in addition to the dues ordinarily chargeable on the towing vessel.

Publications Received

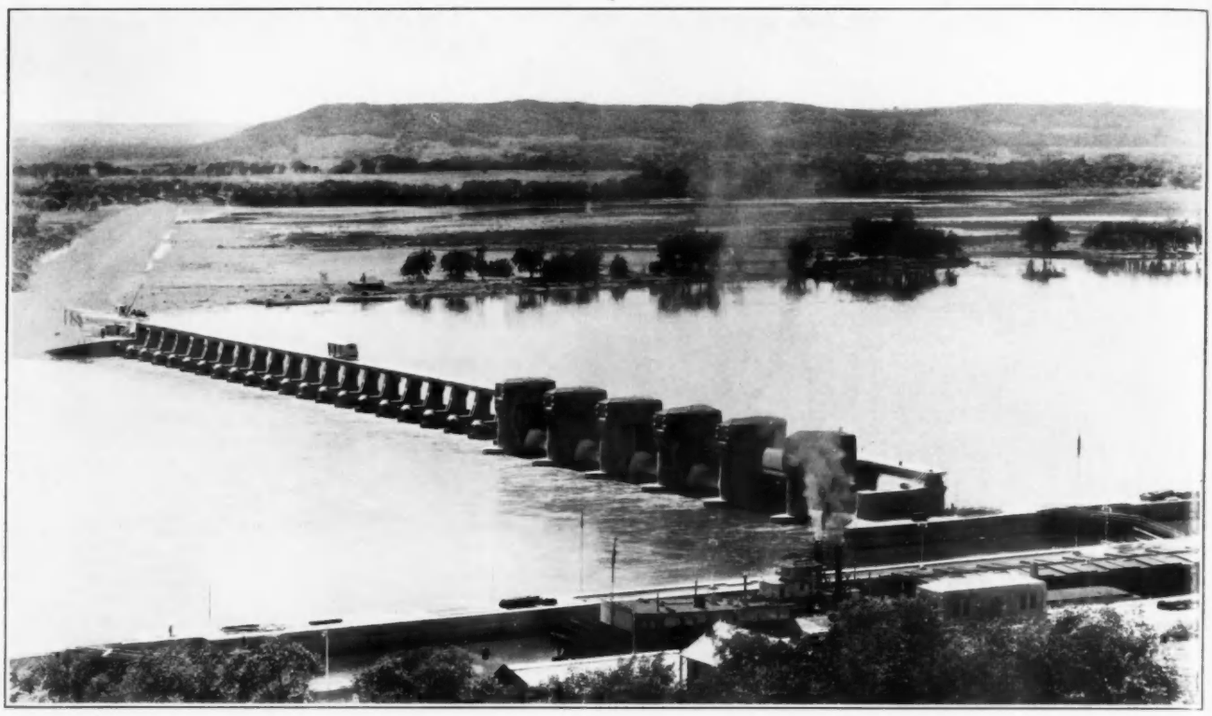
From H.M. Stationery Office has been received a large coloured **Chart of the Seas of the World,** bearing the publication number B.R. 135 (Price 3s. 6d. net), and indicating geographically the position of every British Empire vessel of over 3,000 tons gross register on 24th November, 1937. It is accompanied by a folio of printed text analysing in detail the carrying trade of these vessels. The chart, which has been prepared by the Admiralty, conveys a vivid impression of the extent and vital importance to the Empire of British shipping, and is intended to indicate the nature of the protective task of the British Navy in safeguarding the enormous volume of sea-borne commercial traffic, upon which the safety and welfare of the country depend.

As shown on the chart, the number of British vessels of the tonnage and on the date indicated, was 2,476, of which 1,771 were at sea and 705 in port. Compared with a previous census on similar lines on March 7th, 1936, there was a slight increase of 19 vessels, but it has to be pointed out that the 1937 figures relate to a period when a trade boon was at its peak, and that since then there has been a decline.

As regards the commodities conveyed to this country, it is of interest to note that the whole of the jute imports come from India; 35 per cent. of the wheat comes from Canada, and 23 per cent. from Australia; 39 per cent. of the wool comes from Australia, and 23 per cent. from New Zealand; 57 per cent. of the tea comes from India, and 29 per cent. from Ceylon; 31 per cent. of the meat comes from the Argentine, and 30 per cent. jointly from New Zealand and Australia; 83 per cent. of the maize comes from the Argentine; 46 per cent. of the cotton comes from the United States of America; 59 per cent. of the cheese comes from New Zealand, as also 32 per cent. of the butter; while British East Africa accounts for 90 per cent. of the cocoa, and 42 per cent. of the coffee. This is only a short selection from the figures tabulated, which should prove of great interest to all who are concerned in British overseas trade.

The Revué Statisque (Statistical Review) of the Autonomous Port of Havre for the year 1937, embodies a great deal of tabular information respecting the shipping and commercial movements at the port. The general movement at the port for the year was: 23,124,258 net register tons of shipping; 8,080,214 tons of goods, and 334,055 passengers, of which sea traffic accounted for 22,065,483 net register tonnage of shipping; 6,334,249 tons of goods and 334,055 passengers. There is a decrease in the shipping movement as regards the number of vessels (5.5 per cent.), but a slight increase of 1.7 per cent. in the tonnage, compared with the figures for 1936. The sea-borne traffic constitutes a fresh high record, and compares with 6,009,297 tons in 1936.

The International Labour Office of Geneva, Switzerland (with a branch office at 12, Victoria Street, London, S.W.1), publish a weekly statement of **Industrial and Labour Information** (Price 8d.), which deals with various features of employment and labour organisation throughout the world. The issue for November 14th contains a report of the 85th session of the Organisation which was held in London from 25th to 27th October last, and was noteworthy by reason of the inauguration of a new International Public Works Committee set up to promote international co-operation concerning public works.



Dam on Upper Mississippi River

*Planning and Development of Waterways and Harbours as National Projects**

By Major General JULIAN L. SCHLEY, Chief of Engineers, U.S. Army.

Growth of National Policy

The present national policy for the improvement and maintenance of waterways and harbours by the Federal Government, with the aid and active support of the local interests benefited, is the outgrowth of over a century's development which, beginning with feeble indications of national interest, has gradually developed into the broad and comprehensive programme now in evidence.

The first distinct Act of Congress for the improvement of navigation is dated 1824. The Act provided $75,000 for "removing sand bars from the Ohio River and planters, sawyers, and snags from the Mississippi." In the same year, Congress authorised surveys and estimates for such roads, canals, and rivers as the President might deem of national importance. This survey and report was made by the Corps of Topographical Engineers of the War Department and marked the first assignment of the organisation which since that date has been charged with the improvement of our rivers and harbours in the United States.

Due to the almost complete lack of natural harbours suitable for commercial use on the shores of the Great Lakes, provision of adequate facilities received the attention of Congress early in the last century. Works at Erie Harbour were initiated in 1824, improvements at Chicago, Lorain, Cleveland and Buffalo followed within a few years. It was not long before the increased size of Lakes vessels emphasised the need of substantial outer breakwaters to provide safe anchorages. To-day, many of the magnificent breakwaters seen on the Great Lakes are extensions and reconstructions of the early stone filled timber cribs.

It has indeed been a far cry from the first appropriation in 1824 to the present comprehensive development and programme for future improvement. There are approximately, 1,000 approved river and harbour projects now before the department. This list has grown from the handful of projects constructed to meet the most urgent needs of a century ago at a few isolated locations to waterway improvements in all parts of the country. It includes harbours on our sea coasts capable of accommodating the largest vessels in use; channels and harbours in the Great Lakes designed to meet the needs of the tremendous commerce carried on with a distinctive and highly specialised type of carrier; suitable, reliable channel depths in the principal rivers; and a system of interior intra-coastal waterways along most of the Atlantic and Gulf Coasts.

* Address delivered at the 27th Annual Convention of the American Association of Port Authorities in St. John, N.B., Sept. 12th, 1938.

Growth of Commerce

The analysis of the commercial results is striking. Self-sustaining as we are in most of our needs, our foreign commerce, whether in our own ships or those of foreign countries, is essential to our well-being. The largest vessel entering New York up to 1830 was 600 tons with a draft of 18-ft. In 1884, the largest was 8,000 tons with a draft of 26-ft. Vessels of over 70,000 tons with a draft of 40-ft., now use this great port. Our foreign commerce amounts to over 70,000,000 tons per year with a value of over $6,000,000,000.

Equally important to our well-being is our coastwise trade. The movement of commerce up and down our coasts has steadily increased from 45,000,000 tons in 1921 to nearly 130,000,000 tons with a value of $5,000,000,000 in 1936, in tonnage nearly twice our foreign commerce. Modern deep-draft vessels carry petroleum products from the South-Western oil fields to the populous eastern seaboard at a fraction of the cost of transportation by other means. In recent years, deep-draft, coal-carrying ships have entered the trade with a substantial reduction in carrying costs.

One of the most outstanding examples of a highly-developed water transportation system is that on the Great Lakes. The principal supply of iron ore in the United States is on Lake Superior at the head of the Great Lakes system. To the South are the great coal fields extending from Illinois to Pennsylvania. Iron ore is transported in deep-draft vessels from the ore ports on Lake Superior to the ports on Lake Erie and at the South end of Lake Michigan, where it feeds the smelters of Cleveland, Buffalo, Pittsburgh, Chicago and Gary. On the return journey, the vessels carry coal for distribution throughout the North-West. It is interesting to note that the cost of carrying a ton of coal on these vessels 1,000 miles from Buffalo to Duluth is less than the charge for moving it from the sidewalk to the cellar of a residence. Besides the coal and ore traffic, the Great Lakes system affords low price transportation of grain from the great grain fields of the North-West to the Atlantic seaboard and foreign ports. The water-bourne traffic on the Great Lakes amounted to over 160,000,000 tons in 1937. Computation shows that the national economy achieved by use of the improved harbours and channels on the lakes in reduced cost of transportation as compared with costs of other means of transportation amounts to over $200,000,000 annually. In contrast, the total Federal expenditure on the improvement of these channels and harbours for more than 110 years has been less than this annual saving. The annual cost of maintenance, including operation of the locks at the Soo, is only $3,000,000.

The commerce on our inland waterways has increased twofold in 15 years to an all-time high of 276,000,000 tons in 1936. This growth well portrays the increased use of our rivers, canals and connecting channels and the need for their continued development and maintenance by the Federal Government.

To summarise these figures, I may point out that the total commerce carried by water on our harbours, rivers and waterways in the United States amounts to over 500,000,000 tons per annum, with a value of over $17,000,000,000. This great water transportation system is an essential factor in our national

Planning and Development of Waterways and Harbours—continued

welfare. It reduces the cost of nearly every article consumed by the public.

The Planning and Execution of Work by the Corps of Engineers

In Governmental or business affairs of great magnitude, planning is essential to wise development and efficient management. In a form of Government such as ours, however, planning is necessarily restricted to the extent to which the prescription of general policies has been delegated by the Congress. In a country as extensive as the United States embracing such a variety of topography and diversity of needs, complete integration of planning by a central agency is difficult. To deal with this problem, the Engineer Department is organised into 45 districts, which are effective, regional planning agencies for definite water sheds. Correlating the efforts of these regional agencies are 11 larger territorial agencies known as divisions, which integrate the plans of the districts where these plans have geographical unity. Over all is the co-ordinating authority of the office of the Chief of Engineers, which standardises the efforts of the subordinate planning and correlating agencies. To assist the Chief of Engineers in the national planning of river and harbour works, Congress in 1902 provided for the Board of Engineers for river and harbours, now composed of 7 senior officers of the Corps.

In the execution of its work, as in planning, the Engineer Department has properly decentralised its activities. The design and construction of engineering works embraced by projects within a given district are the responsibility of the District Engineer. The maintenance and operation of completed works are similarly the responsibility of the local District Engineer. All designs and specifications emanating from the district are thoroughly checked and reviewed in the Division Offices and in the office of the Chief of Engineers.

I would like to stress the composition and duties of the Board of Engineers for Rivers and Harbours. This Board, which is in effect a national planning board for the development of our waterways, is composed of seven specially selected officers of the Corps of Engineers with long and varied experience in river and harbour work in many sections of the country. It is free from local partisanship and thus capable of evaluating projects on a national basis. It combines and studies the commercial statistics of our ports and waterways and is thus able to forecast the future intelligently. This Board is of great assistance to the Chief of Engineers in co-ordinating and developing future programmes and represents to many minds a true planning board in every sense of the expression.

How Projects are Selected

There is no need for me to recount in detail how our Federal waterway projects are selected, because you are already familiar with it. It is sufficient here to say that, at the instance of local interests, their representative in Congress takes the initiative by causing the Congress to call on the Corps of Engineers to study and report on the project. This study, conducted after a local public hearing, is twofold—first, on the engineering practicability of the plan, and second, on its economic soundness (i.e., whether the benefits exceeding substantially the cost). If the study shows that the project fails to meet these two tests, the report to Congress is unfavourable. If, on the other hand, it is found to meet these tests, the report of the Engineer Department recommends adoption of the project by Congress. After such adoption, and not until then, are we authorised to expend on it funds subsequently appropriated.

The Bonneville Project. Aerial view from Oregon Side. General view downstream of Power-house superstructure, Lock Chamber and Bradford Island fishladder system

In the conduct of all this work, field representatives of the department are brought into constant contact with the public they serve. This close relationship is a material aid in clearing up local problems and in enabling the department to anticipate the needs of navigation. The Division and District Offices of the Corps of Engineers are always open to the public and the personnel of these offices are fully responsive to their duties as public servants.

The " Port Series "

The Board of Engineers for Rivers and Harbours is entrusted with another duty of particular interest to the American Association of Port Authorities—one, no doubt, with which most of you are familiar. I refer to the investigation of commercial and transportation conditions and facilities at our ports and terminals with a view to encouraging and promoting the development of adequate installations. The reports thereon are known as the " Port Series."

Information on some 100 ports of the United States has been collected and published in 32 volumes by the Engineer Department in co-operation with the United States Maritime

Planning and Development of Waterways and Harbours—continued

Commission. Similarly, data on transportation and transportation lines on the Great Lakes and on the Mississippi and Ohio Rivers has been collected and published. Information on port and terminal charges, shipping charges of United States and foreign ports and regulations pertaining to free ports is made available in published form.

These publications, which are made possible only through the co-operation of the various port authorities of the United States, contain a wealth of valuable information. I am told that some of the "Port Series" are used as texts in courses on transportation in many of our leading colleges and universities.

St. Mary's Falls Canal, Michigan, Lock Entrances

Recent Waterway and Harbour Developments

The improvement of our waterways and harbours is a branch of engineering demanding especial experience and skill. Much of the work is not spectacular and is for ever hidden below the surface of the water. Only the navigator who moves his ship in safety through which formerly were hazardous channels fully appreciates the scope and benefits of the work.

Of the many waterway and harbour projects undertaken during the recent period of accelerated public construction, several of major importance have been completed or will soon become fully available to the public. Work is actively in progress on the enlargement of the Cape Cod Canal to afford within a year a depth of 32-ft. and a width of 500-ft. Boston and New York Harbours have received increased channel and anchorage facilities. The improvement of the New York State Barge Canal from the Hudson River to Oswego on Lake Ontario is progressing at a satisfactory rate. The 27-ft. channel in the Chesapeake and Delaware Canal is practically complete.

Projects for greatly improved channels have been provided or are nearing completion in the St. John's River to Jacksonville, the Sabine-Neches Waterway, and the Houston Ship Channel in Texas. All of the 26 locks and dams required for the 9-ft. channel in the Upper Mississippi are completed or under construction. The new locks and dams and other work on the Illinois Waterway will be available in time to insure a stabilised 9-ft. channel when the limited diversion of waters from Lake Michigan becomes effective December 31st, 1938. The release of water now being impounded by the Fort Peck Dam will result in improved navigation conditions on the Missouri River. Increased channel and harbour facilities have recently been provided at many localities on the Great Lakes. The completed breakwater in the outer harbour at Los Angeles affords a protected anchorage for vessels of maximum draft. The Bonneville Dam, affording extension of deep-draft navigation on the Columbia River from the Pacific Ocean through the Coast Range of Mountains to the Dalles, is practically complete. In addition to these numerous important improvements, increasing attention has been given in recent years with changing economic and social conditions to the need for providing adequate channels and harbours for small craft in the fishing industry and for recreational use.

In the foregoing discussion, I have endeavoured to show that the development of waterways and harbours has not been haphazard nor a matter of chance, but has been based on definite planning under an established policy carried on by the same organisation for a period of over 100 years, under the direction of the Congress. The result of this policy has been to provide, in the United States, port and water facilities adequate to the growing needs. Without that national policy, it seems unnecessary to ask what would be the position of our foreign and domestic commerce to-day.

In closing, I wish to express my admiration for the work of your Association, and of its constituent elements, and its many members, and my appreciation for their aid in furthering the development of our waterway and harbour programme. I look forward to continued pleasant relations as from time to time our mutual interests bring us together.

Correspondence

To the Editor of "The Dock and Harbour Authority."

Metallic Corrosion in Sea Water

Dear Sir,—The article on "Deterioration of Structures in Sea Water" which appears on page 26 of your November, 1938, issue, suggests to me that you and your readers might be interested in certain tests of the corrosive action of sea water on metals which were made at Eastport, Maine, in connection with the Passamaquoddy Tidal Power Project.

I was in charge of that project as District Engineer from its beginning in 1935 to its close in 1936 when it was shut down due to lack of funds.

The construction of a Tidal Power Project in comparison with an ordinary fresh water hydro-electric development introduced many problems outside the scope of established practice. One of the conditions met was that of determining the corrosive action of salt water upon the filling gate structure, water turbines and auxiliary equipment. Little reliable information could be found on the behaviour of metals in sea water other than a few published reports of the British Institution of Civil Engineers and certain committee reports of the American Society for Testing Materials, and these did not cover the severe conditions existing at Passamaquoddy. There the temperature range is from 40° F. to 100° F.; the tides range from 12 to 30-ft., with an average tide difference of 19-ft.; and the sea water is slightly alkaline, almost the same as deep sea water, whereas most waters along the coast lines are slightly acid.

Confronted with these factors, we determined upon establishing our own metals corrosion laboratory at Eastport where we could conduct actual tests under existing conditions in order to select materials and prepare specifications for equipment and material. From various manufacturers we obtained recommendations and secured samples of recommended materials for tests. A special design of specimen was prepared which was more suitable for cast materials than the usual disc type specimen. Four individual specimens of each type were used, one set being submerged, one located at mean tide level, one exposed in the air above high tide, and the fourth maintained in the laboratory as a control for standard comparison with the other three. Approximately 180 different types of materials comprising nearly 1,000 individual specimens were received for test. Specimens were classified in eight groups for non-ferrous materials and eight groups for ferrous materials. In addition to single exposure tests, combinations of dissimilar metals were set up to determine the amount of accelerated corrosion resulting from electrolysis. Additional tests were conducted to study the protective action of zinc when attached to metals, and a number of specimens of paint and other protective coatings were also exposed, and the results studied.

Specimens were accurately weighed before initial exposure, were visually inspected at regular intervals, were photographed at the end of the year's period, cleaned, weighed to determine weight losses, and again photographed. In this way a complete story, both pictorially and quantitatively, has been obtained. A report describing conditions existing after one year's exposure has been published by the U.S. Engineer Office, Eastport, Maine, and is available for study on application by interested individuals.

It is evident that some metals and alloys and combinations of metals and alloys offer greater resistance than others to corrosion and pitting by salt water.

In general, our tests confirm the conclusions expressed in your article, as we found in the ferrous groups that the smallest unit weight losses occurred in the specimens of Chrome Steel and Chrome-Nickel Steel. In the former the best results are shown in all exposures by the specimens with the highest chromium content (11—17%). Two chrome-nickel steel specimens, one with a 19-11 Cr-Ni content, and the other with an 18-11 Cr-Ni content appeared to offer greater resistance to corrosion than specimens of other classes either ferrous or non-ferrous.

The results are, of course, not conclusive, as several years of exposure will be required for proof. Specimens were all reinstalled in the test racks after the first annual examination, and the tests will be continued for ten or more years with periodic inspections to note changes which may occur.

We believe that the results then obtained will be of considerable benefit to engineers who design structures which will be exposed to the action of sea water.

Sincerely yours,

PHILIP B. FLEMING,

Lt.-Col., Corps of Engineers,

District Engineer.

War Department.
United States Engineer Office,
615, Commerce Building,
St. Paul, Minn.

November 17th, 1938.

The Development of the Floating Pneumatic Grain Elevator*

By Dr. CARL A. E. MUELLER, V.D.T.; V.B.T.; H.T.G.; (Brunswick)

GERMAN and English engineering skill shared in the pioneer development of floating pneumatic grain elevators, as well as in the investigation of the processes involved.

Each of the two countries has gone its own way, although ever and again one finds a reciprocal influence in the choice of structural features. The following description will therefore discriminate between English and German elevators. Elevators recently built on the Continent outside of Germany derive, with one exception which will be specially mentioned later, from those which originated in Germany, so that they cannot be regarded as specially developed.

A Fundamental Discovery

Up to the end of the 70th year of the last century, it was possible to trace investigations which were made, in Europe and America, with the object of applying a rapidly moving air stream to the conveying of granular materials, but these led to no useful results. At the beginning of 1890, Mr. F. E. Duckham, then Chief Engineer and later Manager of the Millwall Docks, happened to make a fundamental discovery. He had since 1888, together with Mr. F. S. Tuckett, then Director of the East Ferry Road Eng. Works, Ltd., of Millwall, interested himself in this question. It made the operation of a pneumatic conveyor certain, and was successfully applied to the first floating grain elevator, the "Mark Lane No. 1."

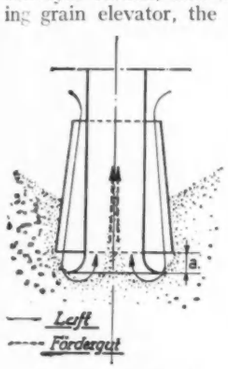


Fig. 1. Diagram of a Suction Nozzle

This discovery relates to the two most important points in a pneumatic plant, namely, the inlet and outlet respectively of the air stream which serves as the conveying medium. By means of it, the uniform and undisturbed conveyance of grain first became possible.

The different kinds of grain of different species, as well as the varying density, with which the grains pack according to their cleanliness, make it necessary to regulate the ratio of the volume of air to that of the grain, so that the largest possible quantity of grain will be carried. Mr. Duckham achieved this by surrounding the suction-head of the conveyor pipe with a second tube.

By varying the axial distance of the conveyor pipe below the lower edge of the outer tube, the slipping of the grain down its slope is varied. The indrawn air flows unrestrictedly into the annular space independently of the depth to which the nozzle is pushed into the grain, and can also be varied in quantity by a regulating ring at the upper end of the outer tube, controlling the openings by which the air enters.

A further difficulty to be overcome was the provision of a good flexible, and yet uncrackable, pipe for the suction line. It had already been attempted to make rubber joints armoured with iron wire, but the rubber of that time was not sufficiently uncrackable. Mr. Duckham provided a movable tube, which consisted of a series of conical lengths of pipe, covered with an air-tight casing. This method proved sufficient to meet all demands, and to this day continues to be generally applied.

For the discharge of the grain out of the hopper at the end of the transmission pipe, into which the air, on account of the diminution of velocity caused by expansion of the cross section, permits the grain to fall, Mr. Duckham placed a valve which operated without any external force and provided a perfectly air-tight joint against the external air pressure. A receiver consisting of two chambers oscillates backwards and forwards, automatically air-tight, under a cylindrical surface, whereby the chambers were alternatively filled and emptied.

The motion was for a time induced by means of the excess weight of the filled chamber. In England, this form of valve was generally adhered to, but furnished, in accordance with the design of the late Mr. A. H. Mitchell (then a Resident Engineer in the service of the Port of London Authority), with a mechanism operated by an electric motor, so that the bucket motion was forcibly produced. Alternatively, there was substituted for the valve a mechanically-operated circular drum with cells, in an air-tight housing. This method has been exclusively applied in Germany for many years.

The First Floating Pneumatic Elevator

In 1893, Mr. Duckham put into operation the first floating pneumatic grain elevator, "Mark Lane No. 1."

This elevator was built by the East Ferry Road Engineering Works, Ltd., of Millwall. The pontoon was 52 metres (170 feet) long and 5.7 metres (18½ feet) wide, containing the boiler and engine plant. The latter consisted of a horizontal condensing compound engine, the pistons being directly connected to the air pumps.

On the deck of the pontoon were three timber tower frames, each of which carried two receivers. The automatic bucket valves required no special drive and therefore no separate mechanism. No steam-driven anchor and mooring winches were provided on this elevator.

One suction trunk was provided for each tower, which was connected to one of the two receivers according to which side of the pontoon the grain was to be discharged.

Under each receiver were four balances to weigh off in lots of 250 lbs., according to the rules of the London Corn Exchange. The maintenance up to the most recent times of this extremely limited unit of measurement has seriously restricted the efficiency of operation. Fig. 5 shows that only the one series of receivers was provided with masts for the suspension of the suction trunk and the stays holding same. The elevator also always lay with the same side against the ship to be discharged. The lighter to be loaded lay either between the elevator and the ship or on the outer side of the elevator. With one suction trunk the output attained 35 tons per hour, and with all three trunks 100 tons per hour.

Special noteworthy is a remark made by Mr. Duckham in 1893, in the course of a discussion on the "Mark Lane No. 1," that he was convinced that pneumatic conveyance was applicable to every kind of loose granular material. Nevertheless, almost two decades elapsed before this suggestion was acted upon.

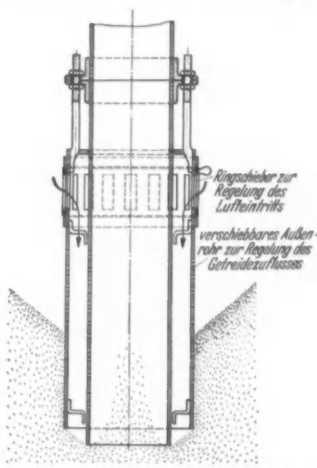


Fig. 2. Duckham's First Suction Nozzle

The "Baltic"

Twelve months after the commissioning of the "Mark Lane No. 1," the elevator "Baltic" was supplied by Mr. Duckham to the Royal Albert Dock.

The illustration (Fig. 6) shows that already marked developments have occurred as compared with the "Mark Lane No. 1." There are only two towers, which are still of timber, but they have been given greater height. The pontoon has been correspondingly shortened, its length amounting to 35 metres (115 feet), and its breadth 6.7 metres (22 feet). The machinery still consists of a horizontal two-cylinder compound engine, but the piston rods now operate two air pumps, which are pairwise connected to each receiver.

The output is correspondingly greater than that of the "Mark Lane No. 1." At the acceptance trials one tower lifted 96 tons of buckwheat per hour, and the two towers together 180 tons per hour. In each tower on each side there were five balances to take a load of 250 lbs. at each filling. For moving the elevator there were steam-driven anchor winches at each end.

The "Garry Owen"

At the acceptance trials of the "Baltic" an experiment was made, in which the "Mark Lane" and "Baltic" were coupled together so that it was possible to blow out and suck in the grain simultaneously. The result of this experiment was so informative that Mr. Duckham, on the basis of the experience gained, in association with East Ferry Road Works, built in

*Translated from the German original in the Jahrbuch der Hafenbautechnischen Gelleschaft, Vol. XVI., published by Julius Springer, Berlin.

Development of the Floating Pneumatic Grain Elevator—continued

1896, the elevator " Garry Owen " for Messrs. J. Bannatyne and Sons, Ltd., of Limerick. This was the fourth of the series, as in the meanwhile Mr. Duckham and the East Ferry Road Works had supplied a third elevator, " Principele Carol," to a Roumanian elevator company for the Lower Danube. This vessel resembled the " Baltic."

A bar in the Shannon River, some 18 sea miles below Limerick, prevented deep-laden grain ships from reaching Limerick, and it was necessary to lighten these ships below the bar at Bligh Castle. It was there that the " Garry Owen " was to serve. The pneumatic plant was erected in the 52-metre (170 feet) long hull of the " Saxon," which in 1847 had been the first steamship to make the journey from England to the Cape of Good Hope.

A horizontal compound steam engine of 440 h.p. drove two pairs of air-pump pistons, which were attached directly to the extended piston rods. Fore and aft of the ship were two low towers, each carrying a receiver and having below an automatic weighing balance of 1-ton capacity.

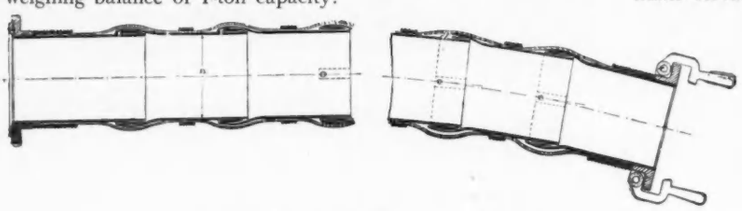


Fig. 3. Flexible Air-tight Knuckle Joint

The arrangement is such that the grain sucked out of the sea-going ship either immediately, without going over the weigh-bridge, runs into the lighter or it is weighed and pneumatically forced into the lighter or to a grain warehouse. The output when operating without weighing amounts to 160 tons per hour and, with simultaneous suction and pressure, about 100 tons. Grain can also be discharged into the hull of the "Garry Owen " itself, and similarly by pressure piping be forced into a warehouse. The elevator was also self-transporting, a vertical compound steam engine of 240 h.p., giving it a velocity of nine knots and allowing it to tow two loaded lighters to the harbour of Limerick. In 1921, this elevator was replaced by a new one of the same name, which is described later.

Subsequent Designs

In 1901, the elevator " Leitrim " was put into operation in the harbour of Sharpness, and is still working. This was one of the first of the elevators similar to the " Garry Owen." It is similarly self-propelling, and can store in its hull, that of an old canal steamer, 600 tons of grain. Of all floating pneumatic grain elevators these two, the " Garry Owen " and the " Leitrim," are the only craft which have been made self-propelling, owing to the local circumstances. All other elevators are moved by tugs.

In the Port of London, five further elevators were installed prior to 1905, this series ending with the elevator " Rapid." Three of them, " Mark Lane II," " Chicago " and " New York " had only one tower with one receiver, but the last two, " Mark Lane III " and " Rapid " again had two towers. The output of these elevators should lie between 100 and 130 tons per hour, but, in practice, scarcely half these figures were reached.

All these elevators were fitted with horizontal engines, except the " Mark Lane III," which had, instead of a slow-running horizontal engine, a vertical engine of about 130 r.p.m., which drove the air pumps through a pinion gearing with a 3: 1 transmission ratio.

In several of these elevators, the suction trunk could be connected to either side of the receiver, spars being arranged on both sides of the receiver for the support of the suction trunk.

When discharging grain, these elevators lay with one side or the other against the ship and work, as it is called in London, " side-on." Correspondingly beneath each side of the tower a series of 250 lbs. scales is placed, the series opposite the side of the ship being used continuously for bagging or loose discharge. In the case of the " Chicago," there was tried for the first time another arrangement, in which the four suction trunks were arranged projecting out over the stern. When discharging, the elevator lays with its stern right up against the ship to be unloaded and operates, as it is called, " end-on."

In such position the elevator can discharge simultaneously to lighters on both sides, a condition which is specially suitable in London where the space is very limited and the boats and lighters are small. All new elevators in London are so arranged. A further advantage is that only a comparatively short part of the ship's length is occupied, so that from the same or an adjacent hatch general cargo can be simultaneously unloaded and put into lighters.

This practice is rarely found on German elevators. Speaking generally, in the Continental harbours the boats are so long that one cannot, as a rule, place them perpendicularly to the ship, and they also could not be so loaded from an elevator, of which the length might be only one-third that of the lighter. Only the elevator supplied in 1913 to the Nord Deutscher Lloyd had to fulfil the requirements that general cargo could be discharged by the ship's derricks from the same hatch as that from which grain was being sucked by the elevator.

In order to achieve this aim, the tower of the elevator must be put back to the end of the pontoon. When the elevator lays oblique to the ship, it is possible to discharge grain and general cargo at the same time.

The Dust Problem

As grave doubts arose concerning the loss of weight in pneumatic elevation, consequent upon the escape of separated dust with the air, from the outset special attention was given to the recovery and re-mixing of the separated dust. For this purpose the air was carried, after leaving the receiver, into a large drum or the air from the exhaust of the pumps was taken through a dust chamber.

In the figures of the elevators " Mark Lane I," " Baltic " and " Garry Owen," can be seen the dust drums, generally called " Cyclones," standing on the deck of the pontoon. In the later elevators a dust chamber was generally adopted. The separated dust was, as a rule, returned to the grain. In Germany the cyclone was built directly into the receiver, which was enlarged to suit. The air entering tangentially was given a rapid rotary motion, whereby the separation of the best part of the accompanying dust was accomplished. This was either introduced into the grain valve, and so once again mixed with the grain, or led outwards through a special valve, after which it was either led back to the grain or kept separate. As already mentioned, the first grain elevators, so far described, were all equipped with horizontal slow-action air pumps, the supply and exhaust of air to which was by automatic flap valves.

Developments at German Ports

Shortly after the installation of the " Mark Lane I," in the Port of London, a licence to employ Mr. Duckham's patent was acquired by the G. Luther Co.'s Machine and Mill Works. This firm had long been interested in the subject, and in the course of years has brought the appliance to a high state of development, with which the names of Messrs. Hugo Luther and Walter Leede are inseparably connected.

This firm built the first elevator for the Nord Deutscher Lloyd in 1896, which closely resembled that which Mr. Duckham had built in London. It was fitted with two towers and had a horizontal steam engine which was directly coupled to a horizontal air pump. The capacity was about 100-120 tons per hour.

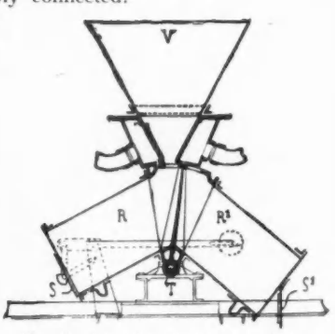


Fig. 4. Duckham's Bucket Valve

The second plant supplied by this firm was for the Hamburg America Line in 1897.

It was the same as that of the Nord Deutscher Lloyd, except that it had no special overlift for the loading of coasting vessels, such as was fitted to the Nord Deutscher Lloyd elevator.

In 1899, each of the two companies obtained still another vessel, of which that of the Nord Deutscher Lloyd had one and that of the Hamburg-America Line two towers. The Nord Deutscher Lloyd elevator had a vertical steam engine for the pump drive. One tower was later removed from the Hamburg-America elevator and placed on a separate pontoon.

It will be apparent that the first German elevators adhered closely to the London vessels in their arrangement. Only the weighing apparatus was made simpler, since it was not restricted by the requirement that the grain should be measured in small lots. One large weigh-bridge was placed under each tower, which could be used only for weighing loose grain, and was not applied at the same time to the sacking of the grain.

In the first London elevators the suction trunk entered perpendicularly into the receiver and could, as already mentioned, be connected to one or the other side of the receiver. If the elevator was out of use, the trunks as a rule were taken down and stowed on deck and the spars drawn up, so that nothing projected over the edge of the pontoon.

Development of the Floating Pneumatic Grain Elevator—continued

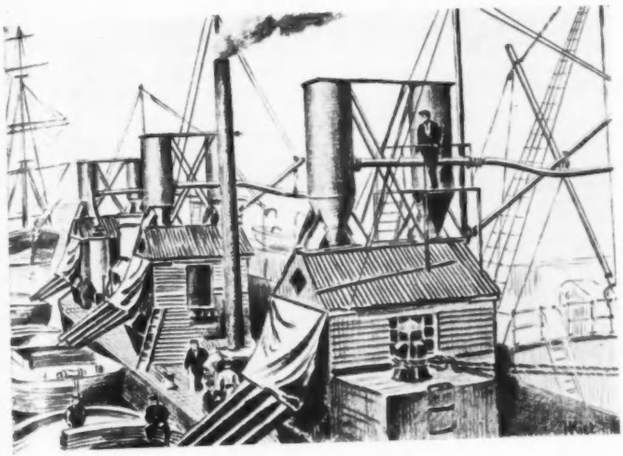


Fig. 5. The Elevator "Mark Lane No. 1" unloading grain. Drawing from a photograph taken in 1893

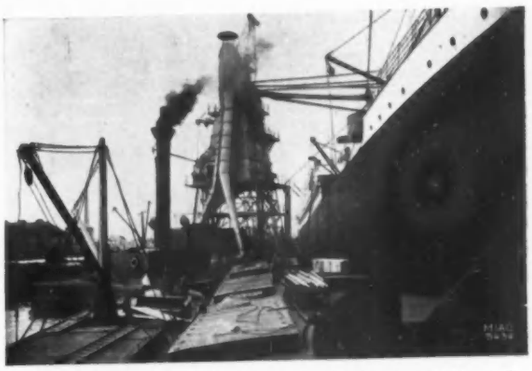


Fig. 9. Elevator III of the N.D.L., discharging grain and general cargo simultaneously from the same hatch.

Fig. 6. The Elevator "Baltic"

Fig. 11. The Hamburg-America Line's First Elevator

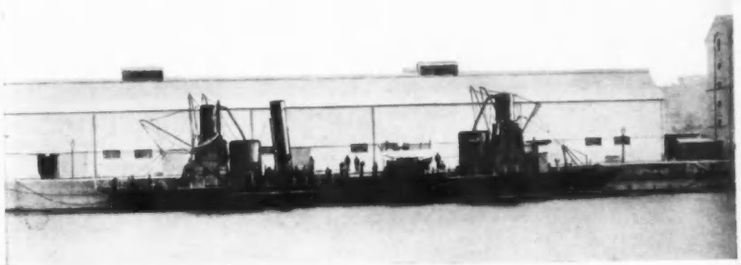


Fig. 7. The Elevator "Garry Owen"

Fig. 10. The Elevator "Nord Deutscher Lloyd" in Bremerhaven

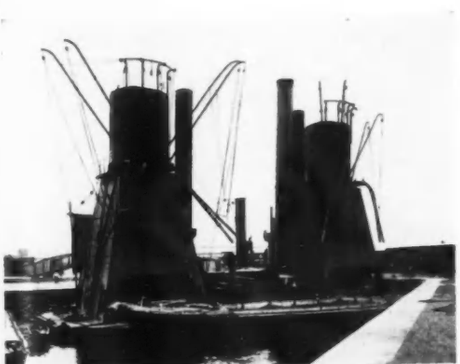


Fig. 8. The Elevator "Mark Lane III."

Fig. 12. The First Floating Pneumatic Grain Elevator in the Harbour of Rotterdam

Development of the Floating Pneumatic Grain Elevator—continued

In the German elevators, from the first, the suction trunks were placed only upon the one side; they hung similarly upon spars, but, however, were not simply connected direct to the receivers, but as is clearly shown on the first Nord Deutscher Lloyd elevator in Fig. 10, were connected to the receiver by a swinging bend. By this means an easy lateral motion through 180° is obtained, and the frequent time-wasting on-and-off coupling of the conduction pipe is avoided. The discharge of the grain is also always on the side away from the suction trunks.

The firm of Luther struck out a new path, which was of great significance for the construction of future German elevators, in the building of the first floating pneumatic grain elevators for the "Maatschapij tot Explotatie van drijvende Elevatoren," later "The Grain Elevator Co." in Rotterdam, in 1905.

Fig. 13. View of the Maas Harbour in Rotterdam, with numerous elevators of the Grain Elevator Company at work

To these two elevators followed, in 1907, those of the Hamburg Grain Elevator Co., which was founded in 1906. In the subsequent years up to the beginning of the World War, there were developed in the ports of Hamburg, Rotterdam, Amsterdam and Antwerp, extensive fleets of elevators, and the ports of Bremerhaven, Emden and Le Havre also obtained elevators, whereas in the Port of London, up to the beginning of the war, no new elevator was put into service ; the number of elevators in the ports mentioned rose to over 80.

German Practice since 1905

In the elevators built in Germany since 1905, the compact form has been abandoned, and towers have been so raised that the largest Rhine and Elbe boats, as well as coasting steamers up to 2,000 tons, can be loaded directly from the weigh-bridge without the intervention of a bucket elevator. The tower stands near the middle of the pontoon, and has the form of a slender frustrum, which carries on its upper surface a receiver fitted with four suction trunks. Below the upper storey is the valve, at first still of the automatic tilting type, and later, constructed as an electrically-driven cell-cylinder valve, which discharges the grain into a spacious container. Out of this it flows to a hand-operated decimal-scale of 2,000 kilograms per load and passes after this weighing through a loading pipe, movable to all sides, down to the lighter.

With the first machines, built in 1905 and 1907, there is a dust container below the weighing room, but in the later elevators it is no longer provided.

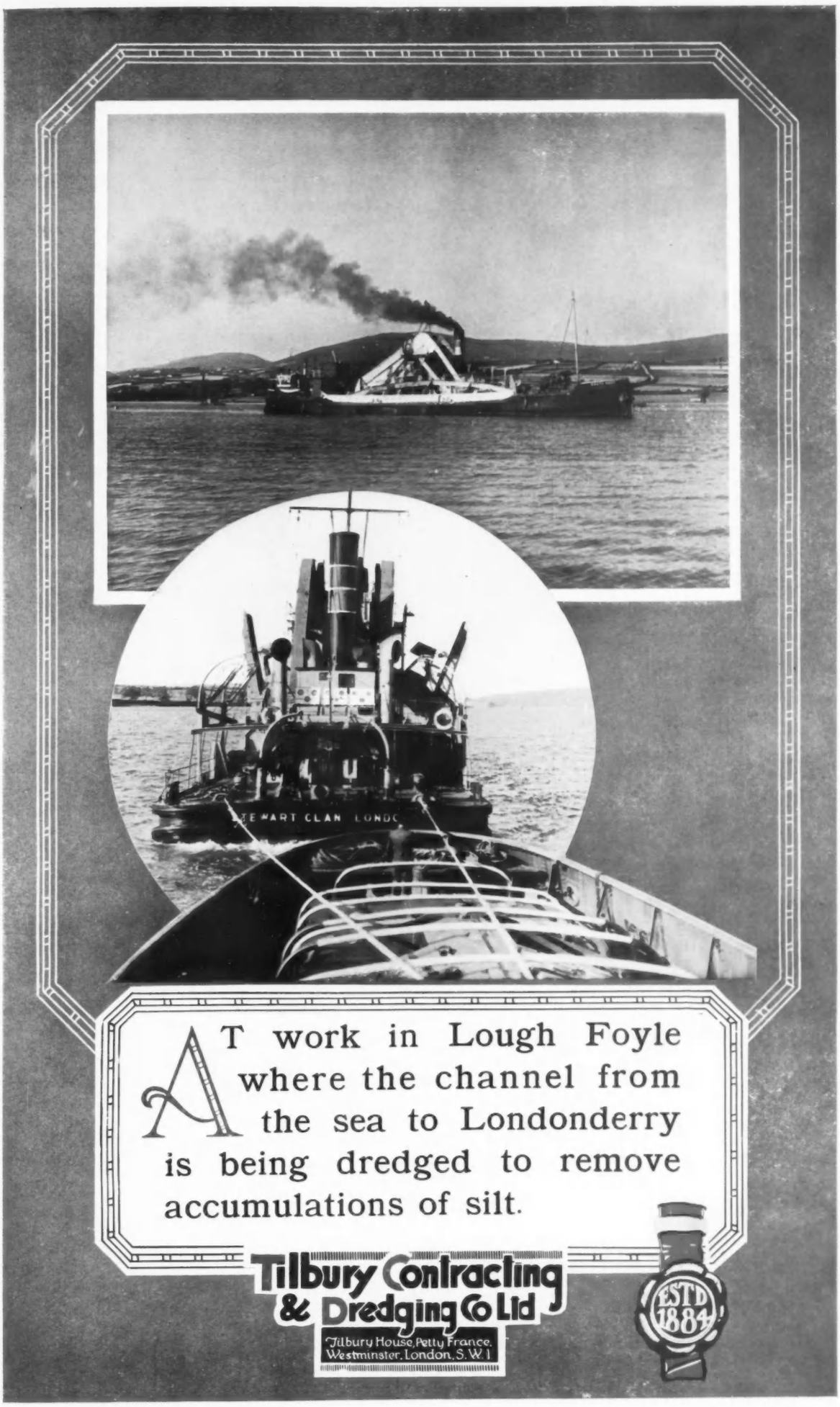
At the same time, the horizontal arrangement of the machinery was abandoned, both the steam engine and the air pump being made vertical. This became possible owing to the greater height of the tower, which permitted a larger and well-lighted engine room. Hence the machinery has assumed the form customary on ships, which makes possible good control and access to all parts of the driving mechanism. Since the beginning of the century the heavy flap valves in the air pumps have been replaced by mobile, small plate valves, which assure an accurate closure and become quite accessible in the vertical pumps.

The operating machinery, a two-cylinder compound steam engine with injection or surface condensation, drives air pumps on both sides through an extended crank shaft. One or two high-speed steam-dynamo sets provide electric current for lighting and, later, for the valve-motor and the suction trunk winches. At both ends of the pontoon there are anchor winches, on the drums of which the ropes are wound for hauling the elevator along the side of the ship to be unloaded. A powerful deck winch is placed on the discharge side, by which the largest Rhine and Elbe boats can be hauled along the side for uniform loading.

Thus, in a short period, there developed the standard form of the German elevator, which has not since changed, although, in the course of years, advancing technique has produced many improvements in the steam engine, the electrical equipment and the winch service. The normal output has increased from the original 150 tons per hour to from 200 to 250 tons, and sometimes, with easy-running grain, may rise to 300 tons or more. With the high position of the receiver, the mobility of the suction trunks is increased and it becomes possible to avoid all unnecessary curvature of the pipes. In the standard form of German elevators, such as have been adopted in Hamburg, Bremen, Amsterdam, Rotterdam and Antwerp, the tower is about 15.5 metres (49 feet) high, and on this is fixed a mast about 7 metres (23 feet) long for the suspension of the suction trunks. The high tower construction necessitates a greater breadth of pontoon, which now amounts to about 10 metres. The only elevators which deviate from this form are the three new N.D.L. ones built in 1913, 1921 and 1928, which were designed for unloading the largest steamers travelling on the North American routes. In view of the great height of these ships, the tower was made 2.5 to 3 metres (8 feet to 10 feet) higher than in the standard form, and the discharge of the suction trunks was also increased. On account of these changes, the breadth of the pontoons had to be enlarged, up to over 13 metres (43 feet), but the length of the pontoon was maintained at 30 metres (98½ feet). In other respects, these elevators are the same as the standard type.

Specially remarkable is the small energy demand of the German elevators as compared with the London ones. While, with the latter, in the most favourable stowing conditions, there was still an energy consumption of 2.5 h.p. hours per ton of grain carried, in the German elevators in the most suitable conditions the energy consumption amounts to 1 h.p. hour or less.

Without doubt, one of the essential factors in this is the generally better efficiency of the vertical engine, together with the high volume efficiency of the pumps fitted with numerous small freely-moving valves. The arrangement of the suction trunk, which was neglected in the first elevators, is also a matter of great significance. *(To be continued).*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L SHED

D SHED

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1100'0"

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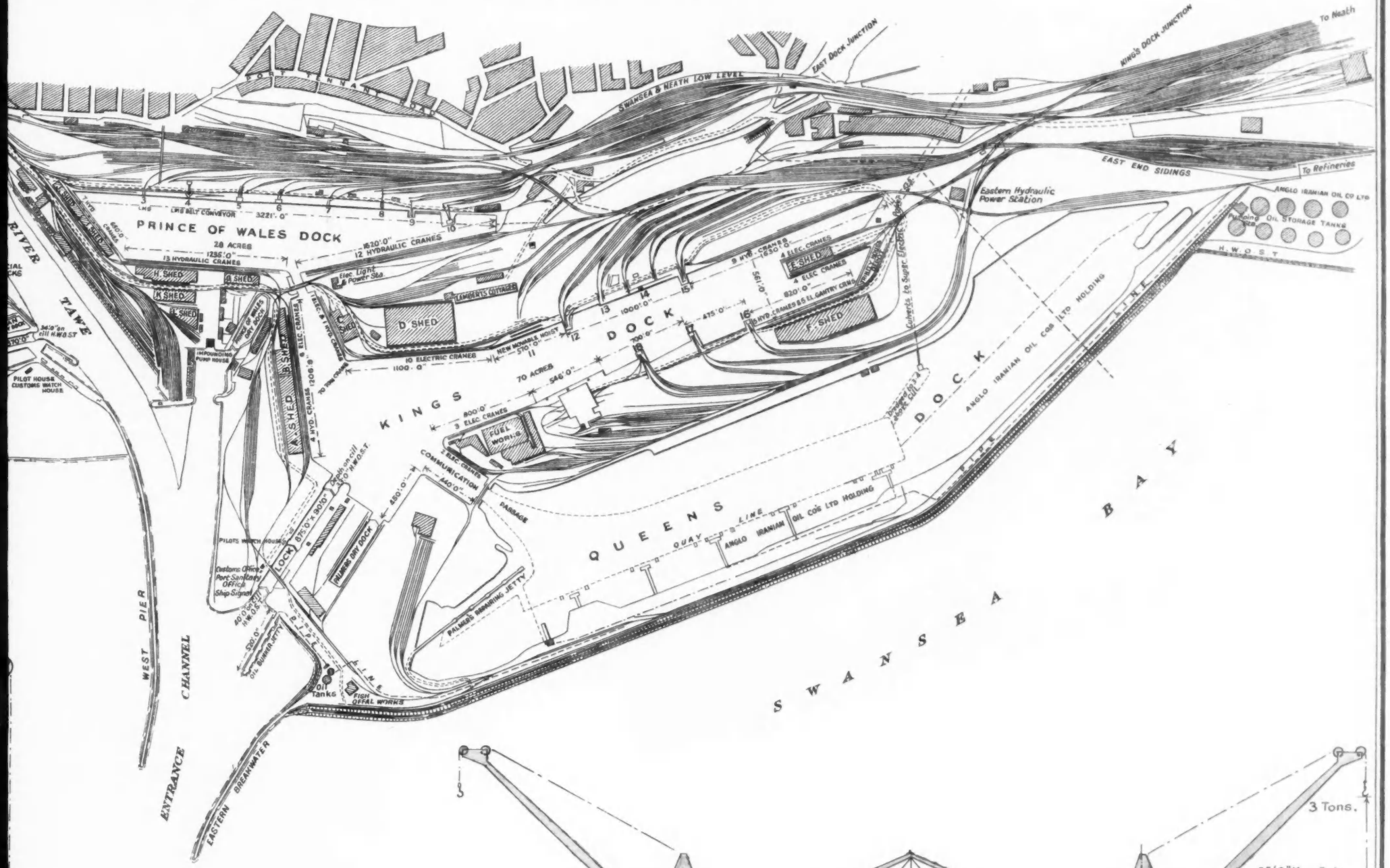

Scale for Plan.

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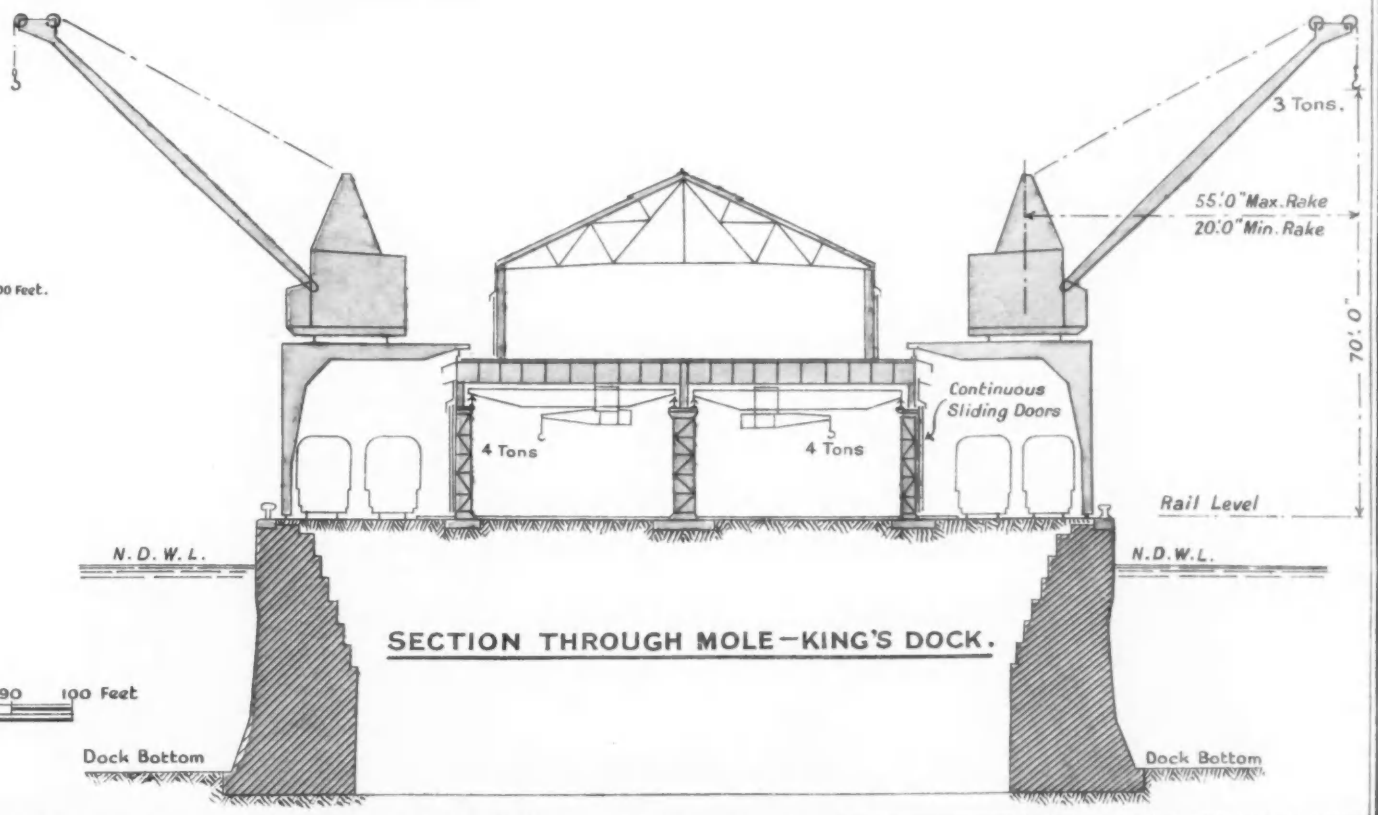
Anti-Breakage Escalator



SECTION THROUGH MOLE—KING'S DOCK.

Scale for Sections.

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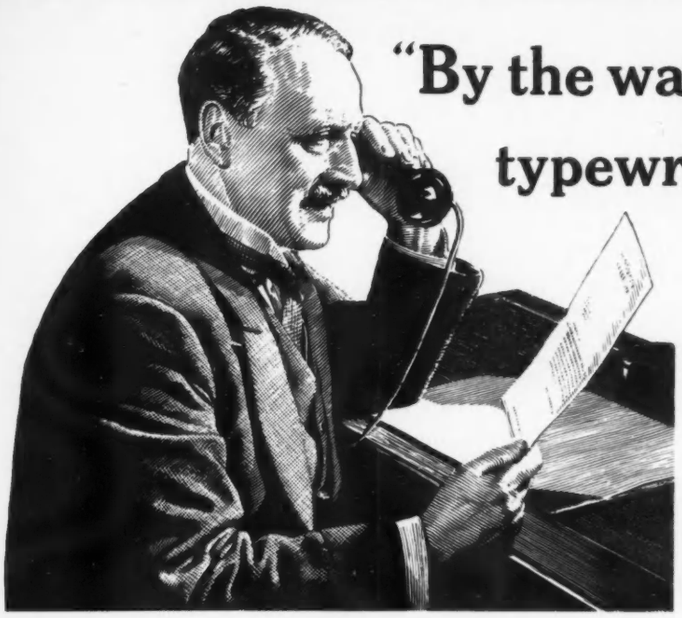

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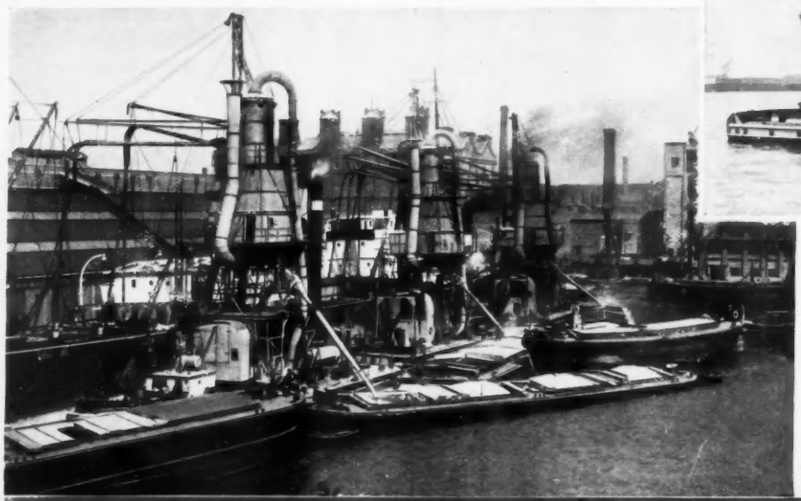

MIAG floating pneumatic Grain Elevator of the North German Lloyd at Bremen.

On left : Three MIAG floating pneumatic Grain Elevators of Messrs. United Grain Elevators Ltd. of Liverpool.

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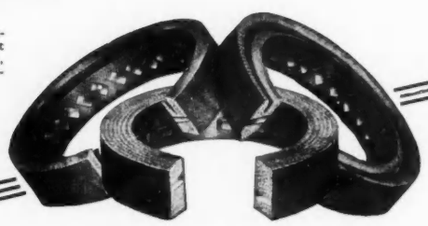

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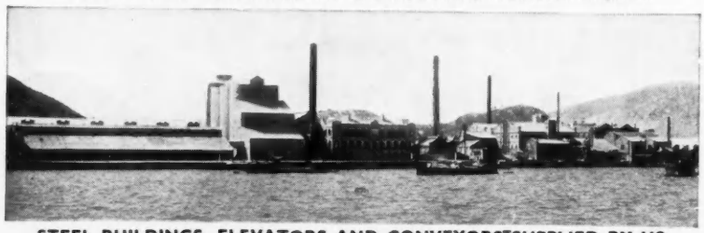

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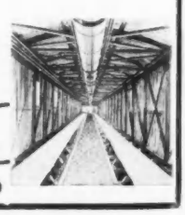

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Notes of the Month

Revolving Light for Slyne Head Lighthouse.

A revolving light, to replace the existing fixed light of 25,000 candle-power, is being installed at the Slyne Head Lighthouse by the Irish Lights Commissioners. The new light is fitted with Parson's mirrors, and will have a strength of 800,000 candle power.

Free Ferry Across the Tyne.

At a conference of representatives of Northumberland and Durham County Councils and Jarrow Town Council, the County Councils decided to grant Jarrow liberal financial assistance in continuing the free ferry across the Tyne until a report is received on the practicability of constructing a tunnel under the Tyne at Jarrow and an estimate of the cost.

Improvements to Mumbles Pier.

The South Wales Transport Co., Limited, have applied for leave to introduce a Bill to Parliament for the widening of the Mumbles Pier, Swansea Bay, on both sides near its shore end. It is proposed to extend the pier on the north-western side in a westerly direction for 95-ft., and on the south-eastern side in a south-easterly direction for 25-ft., and from its south-western end in a westerly direction for 127 yards.

Enlargement of Swedish Floating Dock.

A large floating dock belonging to the Swedish shipbuilding firm, Eriksbergs Mekaniska Verkstad, of Gothenburg, is being enlarged with a view to handling the new Swedish American motor liner "Stockholm." After alteration, the dock will have a length of 643-ft. and a lifting capacity of about 22,500 tons. It is stated that this will make it the largest dock of its kind in Scandinavia.

Impending Harbour Legislation.

Among the bills deposited for the consideration of Parliament next session, are the Maryport Harbour Bill, promoted by the Maryport Harbour Commissioners to make provision with regard to their finances; the Wear Navigation and Sunderland Dock Bill, promoted by the River Wear Commissioners for the purpose of obtaining further powers; and the Port Glasgow Burgh and Harbour Provisional Order. A Bill, promoted by the Dover Gas Company and other parties, seeks to abolish certain duties on coals imported and brought into and landed or delivered within the town and Port of Dover.

Harbour Works and Improvements at S. Antioco, Sardinia.

In a recent edition of "Tribuna" particulars are given of the port development works in progress at S. Antioco, in the south-west of Sardinia. When completed, the new port will handle the total output of the local mines, including coal, production of which it is hoped to increase to three million tons a year. There have already been constructed an entrance channel 2,100 metres long and 60 metres wide, a dock having an area of 22¼ acres, two wharves, one 260 and one 200 metres long, and a breakwater 600 metres long outside the port. The canal and dock have a depth of 8 metres, and the total cost has amounted to 9,700,000 lire. The necessary railway connections involving the expenditure of another 1,800,000 lire, are at present being completed, as well as a fresh-water aqueduct 23 kilometres in length and costing 2,400,000 lire. Two swing bridges, to cost 1,800,000 lire, will shortly be built, and an existing railway wharf is to be demolished and reconstructed at a further cost of 1,800,000 lire.

Impending Developments at the Port of Gothenburg.

Considerable improvements are contemplated at the Port of Gothenburg. The following outline of proposed extension works was given recently in the course of a lecture by the General Manager, Mr. G. Dieden.

It was proposed, he said, to build two new warehouses and expand the existing warehouses in the free port, which will also have an addition of new quays. At Tingstadvassen, north of the free port, it was proposed to construct three new basins. The Gullbergs Quay was to be widened to 540-ft., and the Packhus Quay would be reinforced to carry the weight of several new cranes and new sheds. The width of the Skeppsbro Quay would be extended by about 40-ft., and two new stone piers were to be joined together with a double railway track. The Masthugg Quay was to be broadened and equipped with an additional railway track. The Sannegaardshammen would be extended in length and a new quay constructed on the opposite side of the basin, while about 20 new cranes would be added to the equipment of this section of the port. The Amerikakajen would be lengthened towards the east and equipped with a modern terminal building for the benefit of overseas passengers. Finally, the construction of an entirely new basin at Skarvik was suggested.

Port of Bristol Shipping Returns.

Shipping entering the Port of Bristol during the present financial year is likely to establish a new record for register tonnage, which for the first time is expected to exceed 4,000,000 tons. Last year's total of 3,805,338 tons was the highest recorded since the war. For the eight months to November 30th, foreign register tonnage was 250,000 higher than in the corresponding period of last year.

Improvement Works at Southampton Docks.

Work is to begin at once on important alterations to berths Nos. 34, 35 and 36 in Southampton Docks. A contract has been placed with Sir Robert McAlpine and Sons, Ltd., for the widening of the quayside at the berths mentioned by 35-ft., along a 1,600-ft. frontage. This operation will take, roughly, about ten months to complete. The opportunity will also be taken during this extensive reconstruction of the quay to remove the present 6-ft. balcony along the face of sheds Nos. 35 and 36 at the first-floor level, and replace it with a 15-ft. balcony, which will be supported by steel stanchions.

Mersey Dock Board Election.

At a recent meeting of the dock electors of the Port of Liverpool, the following six retiring members of the Mersey Docks and Harbour Board were re-elected to fill the respective vacancies: Sir Thomas A. L. Brocklebank, Bart., and Messrs. J. B. W. Hughes, M. H. Hulme, F. H. Southern, Alma Parkin and H. Sutton Timmis. At the ensuing weekly meeting of the Board, Sir Richard D. Holt, Bart., LL.D., was re-elected Chairman, with a warm tribute of appreciation to his services in the past, and Sir Thomas Brocklebank was re-appointed Deputy-Chairman.

River Transport in U.S.S.R.

According to reports received, the volume of traffic carried on Soviet rivers between October 1st and November 19th, 1938, was 9,962,500 tons. This is slightly more than the anticipated volume of river transport for the whole of October and November. The extent to which transport on the inland waterways of the U.S.S.R. has increased may be seen from the following figures:—In 1923 the volume of goods carried was 7,500,000 tons; in 1928 it was 18,500,000 tons; in 1932 it was 47,000,000 tons, and since 1933, these figures have grown considerably.

Overhaul of the Gatun Locks.

The quadrennial overhaul of the Gatun Locks is announced to take place during the coming dry season. The actual closing of one side of the locks will be deferred until after the passage of the United States Fleet through the Panama Canal some time towards the middle of January. Immediately transits are again normal, overhaul of the Gatun Locks will commence, when, as customary, only one side of the locks at Gatun will be available for transit until completion of the overhaul. During the overhaul period, Gatun Locks will be operated day and night, and the Pacific Locks also operated in such a manner as to ensure a minimum of delay to merchant shipping.

Operations of the Tees Conservancy Commission.

The annual accounts of the Tees Conservancy Commission for the year ended October 31st last, showed a surplus of £14,808, a decrease of £22,029, compared with the previous year. The number of ships entering or clearing from the river decreased by 200, and the volume of imports and exports was also lower by 240,000 tons and 213,000 tons respectively. In order to stimulate and encourage trade, the Commission is carrying out an important programme of river deepening and improvement, and during the past year, considerable progress has been made with the reclamation of the Seal Sands, while the erection of two new lighthouses and the moving of the Fifth Buoy Light has been completed.

Proposed Single Authority for South Wales Ports.

At a meeting of the local branch of the National Association of Local Government Officers at Cardiff recently, Councillor R. T. Evans, Deputy Lord Mayor of Cardiff, put forward a suggestion for the formation of a single port authority for all the South Wales ports, similar to the system in force at London and the Thames. The subject of dry dock accommodation was also mentioned, and reference made to the proposed conference of the local port authorities (comprising those of Cardiff, Newport, Barry, Swansea and Port Talbot) on the question of additional accommodation. This conference was held at Cardiff on December 29th and took place too late for notice in the current issue of this Journal, but its intention was to impress upon the Government the necessity of taking immediate action in the matter, in order to be ready for any emergency which may arise.

Projected Works at the Port of Havre

Three Experiments with Scale Models recently carried out in the Port Laboratory*

Described by M. FRANCOIS BEAU, Ingénieur-en-chef des Ponts et Chaussées.

IT may be of interest to give a brief account of experiments which have been made with small-scale models in the laboratory of the Port of Havre, in view of new works proposed to be carried out under the direction of M. Despujols, Chief Engineer and Port Manager.

The experiments relate to projects which lie rather outside ordinary current practice and which it would be difficult to deal with by mere calculation. The information derived from the

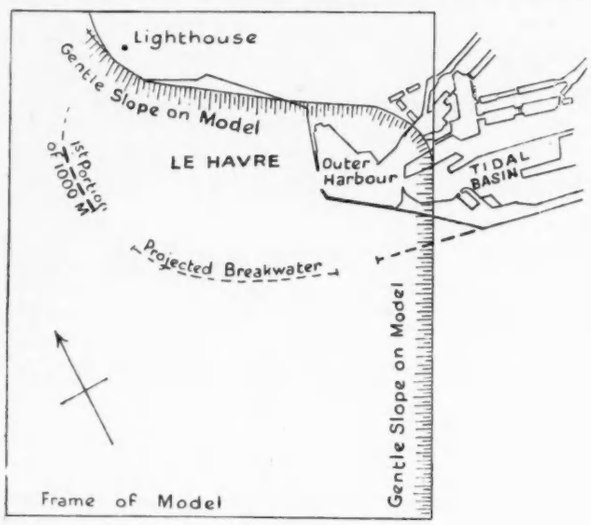


Fig. 1.

models has therefore been very useful in forecasting the effect of the proposed arrangements and reducing the risk involved in treating costly works by methods hitherto untried.

Trials have been made with models of three kinds following:

(1) A small model of Havre Roads, to ascertain the effect, in reducing swell at the harbour mouth, of the partial enclosure of the roadstead by a protecting breakwater;

(2) A dolphin formed by a ring of steel sheet-piling, for mooring, in a tidal basin, large liners of the " Normandie " type;

(3) A quay constructed on the " gabion " principle, with steel sheet-piling.

Of these three projects, only the second is yet in course of execution, and this is the formation of a repairing berth in the Tidal Basin, for which a contract has been let to the Western Contracting Company — Entreprise de Travaux Publics de l'Ouest. Tests of the full-size dolphins can easily be made on completion of the works and comparison of these with the results of experiments on the scale model will be of great interest.

The third model, of which the corresponding work is not yet undertaken, is likewise very instructive, for the adoption of the "gabion" type of quay, as tried out in the scale model, will reduce by more than half the cost of deep-water quays in the Tidal Basin of the port. The saving will be considerable in view of the very high cost of construction by older methods, which would be 150,000 to 200,000 francs per lineal metre (say £250-350 per lineal foot) at present rates.

I.—Small Model of Havre Roads

The widening of the harbour entrance, which was recently increased from 200 to 250 metres by the alteration of the South jetty of the outer harbour, had given rise to some apprehension regarding the safety of vessels in the harbour in a North-Westerly gale. It had been proposed to guard against this danger by constructing, at some distance out in a North-Westerly direction from the shore, a 1,000 metre length of breakwater, that should form the first section of a longer breakwater sheltering the whole bay, this being a very old project which had its first beginning as far back as the time of Admiral Coligny. The intended alignment is shown in Fig. 1.

The part of the bay reproduced in the model is 8 kilometres long and 7 kilometres wide. The depth of water at H.W.O.S.T. is 14 metres, average. The characteristics of the swell in heavy weather are: Length of wave, 40 to 50 metres and amplitude, 3 metres. The model had to be made to the very small scale of 1/1,000th, in view of the respective sizes of the actual roadstead and of the necessarily restricted space available for use. At this scale the depth of water representing the sea ought to have been 14 millimetres and the characteristics of the swell 5 centimetres for length of wave and 3 millimetres for amplitude. This made it very difficult to represent actual conditions in the model. In practice it became necessary to operate with a depth of water of 4 cm. and a wave-length of 8 cm. This unavoidably excessive wave-length in the model tended to make the simulated conditions worse than in reality. But the amplitude became very small indeed at the point corresponding with the harbour entrance, on account of the rapid damping effect due to the excessive viscosity of the water in the model.

The swell was propagated by the oscillation, on a horizontal axis, of a paddle having its length equal to the width of the tank and set in motion by an eccentric driven by electric motor. See Fig. 2.

Measurements of amplitude or height of wave from trough to crest were very difficult to take by reason of their smallness. It was necessary to introduce an optical method, based upon photographing the image of a straight horizontal bar as mirrored on the surface of the water. The reflection on the undulating surface is a line of " sinusoidal " appearance, whose waviness is of much greater amplitude than that of the swell itself, the amplification being accentuated by observation at a low angle. The relation between the two can be readily determined by geometry.

By means of photographs of the reflection of the bar, it has been possible to compare in the model the varying amplitudes of the swell for different positions of the breakwater.

The diagrams in Figs. 3, 3a and 3b, reproduced from photographs, show the effect of the 1,000 metre length of breakwater proposed to be constructed, as described, in the Havre Roads. Though the diagrams showing the swell broken by the breakwater are not so clear as the others, it may be seen that the amplitude is appreciably reduced at the harbour mouth by the breakwater. The photograph in Fig. 4 shows the actual appearance of the water surface. It is easy to see the way in which

Fig. 2. Wave-producing Mechanism

* Translated from the " Annales des Ponts et Chaussées."

Port of Havre—continued

the waves swing round the two ends of the breakwater and the counteraction of the deflected waves, which assists in the dissipation of energy.

The conclusion may be drawn from these experiments that the protection afforded by such a breakwater would be clearly felt at the entrance to the harbour and therefore also within it. It would, however, be impossible to say exactly by how much the swell is diminished, because of the extremely small scale of the model and the uncertainty consequently arising from the effect of the viscosity of the water, which is much more appreciable at the reduced scale than it is at full size.

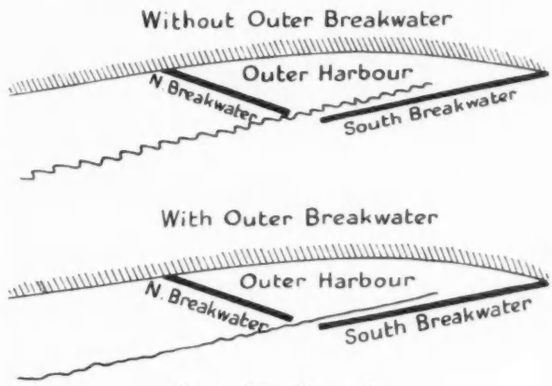


Fig. 3. First Observation

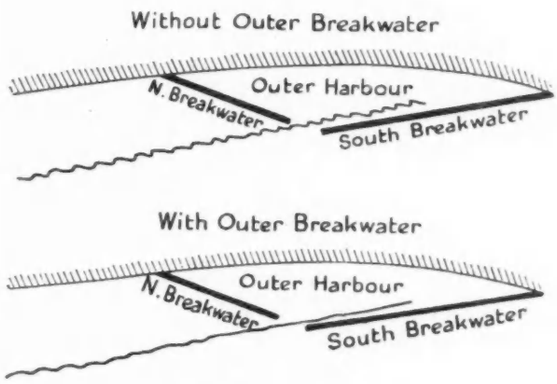


Fig. 3a. Second Observation

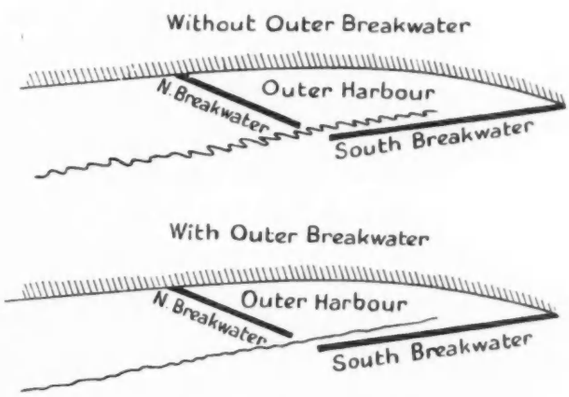


Fig. 3b. Third Observation

II.—Cylindrical Dolphin for Mooring Large Liners.

This work, now under construction in the Port of Havre, is constituted by a cylindrical ring of steel sheet piling, of the Senelle type, 12 metres (40-ft.) in diameter and 25 metres in total height. This casing or shell is to be filled with dredged sand and shingle and the pile heads embedded in solid concrete forming a capping to the structure. The section being circular, the outward pressure of the filling will produce no bending moment in the piles but only a circumferential horizontal tension, which the interlocks of Senelle piling are specially designed to bear. The relative levels of the capping, of high and low water and of the harbour bottom, are shown in Fig. 5. This type of construction, in addition to its low cost, has the advantage of being easily dismantled in case of need.

The dolphin is designed to resist the heavy pull of 300 tons from the cables of a large liner. The calculations for the project show a safety margin of at least 100 tons. The object of making an experiment on a scale model was to verify this, because certain hypothetical factors in the calculations had to be rather arbitrarily assumed.

Fig. 4.
View of Swell, in Model, with Outer Breakwater in foreground

The model was made to the scale of 1/24th, in the manner indicated by Fig. 6. The ring of piling was represented by a cylinder of thin sheet iron, though this had the drawback of failing to reproduce the risk of sliding of the piles at their interlocking joints. This risk will be met in the full-size structure by welding the upper parts of the joints, the welds being proportioned to give a large factor of safety, on account of the indeterminate value of the actual forces to be resisted. The model gave way under a horizontal pull exceeding 40 kilos (90 lbs.) corresponding to a pull of at least 500 tons. It began to yield under a pull of 25 kilos, representing over 300 tons.

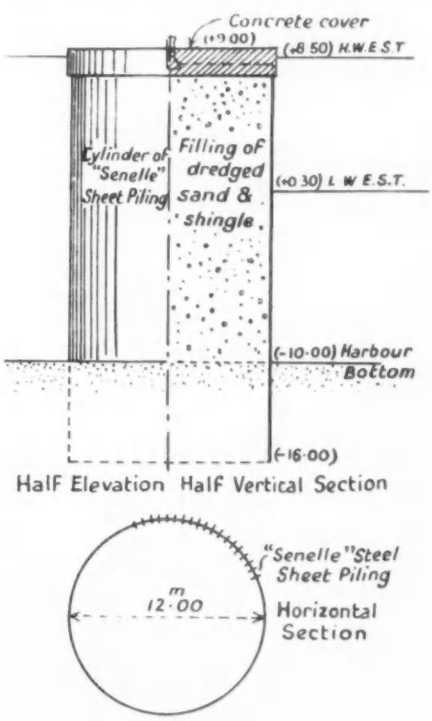


Fig. 5.
Steel Sheet Piling Cylinder Dolphin

An additional experiment was made after attaching a bottom to the cylinder, which had the effect of representing a solid structure. The resistance was not appreciably increased by this addition, a result which confirmed calculation.

III.—Wall of Gabion Type in Sheet Piling.

This type of quay wall is based upon a similar principle to the dolphin already described and comprises a series of cells formed

Port of Havre—continued

of sheet piling, connected laterally and filled by the natural ground or by reclaimed filling. The longitudinal sheets at front and back, which act respectively as quay wall and as anchorage curtain, are segmental in plan. The transverse sheets are straight and act as ties. Owing to this arrangement, the ground pressures induce no stresses in the sheeting except horizontal tension; there is no bending moment. It should thus be possible, with strong interlocks, such as the Senelle pile has, economically to construct walls 25 metres high, like the deep-water quays in the Tidal Basin at Havre.

The small-scale model made in the Havre Port Laboratory related to a length of quay wall, 14 metres high, proposed to be built for widening the passage at the Basin Dock. The gabion type was adopted for this project, although not the most economical for a height of less than 15 metres, in order to gain experience with this type before adopting it for works of the greater magnitude of the deep-water quays in the Tidal Basin.

The arrangement of the model of this passage wall is shown by Fig. 7. The scale of reduction is 1/25th. By simply changing the scale assumed in interpreting the experiment, it is possible to deduce results applicable to walls of greater height. The sheeting in the model was made of strong canvas, stiffened vertically by flexible laths representing sheet piles. It will be noticed that, for the sake of economy, the height of the anchorage curtains and the transverse diaphragms is reduced.

The model was placed in a trough in which the water level could be regulated at will. The cells of the model and the bottom of the experimental trough were filled with very fine sand, having a natural slope of about 25 degrees and without cohesion. Such sand differs appreciably from the clayey sands usually found at Havre, which have a cohesion of 200 to 600 grammes per sq. cm. Reducing this to the scale of 1/25th, the reduction is $(1/25)^2$ or 1/625 or practically nil, so that it is truly represented by the fine sand, except for a small discrepancy in the angle of internal friction, which is too high in the model.

The test load was applied by means of 20 cm. concrete cubes, forming a surcharge. In addition a thin film of water was maintained over the filling in order to give hydrostatic pressure. The movements of the quay were measured at top and bottom by means of horizontal rules, as shown in Fig. 7. The stability exceeded expectations. Up to a load of 2.8 tons per sq. metre, corresponding to 70 tons per sq. metre in reality, movements in the model were negligible (less than 15 mm.) whatever the water level on the face, even in the extreme case of no water at all.

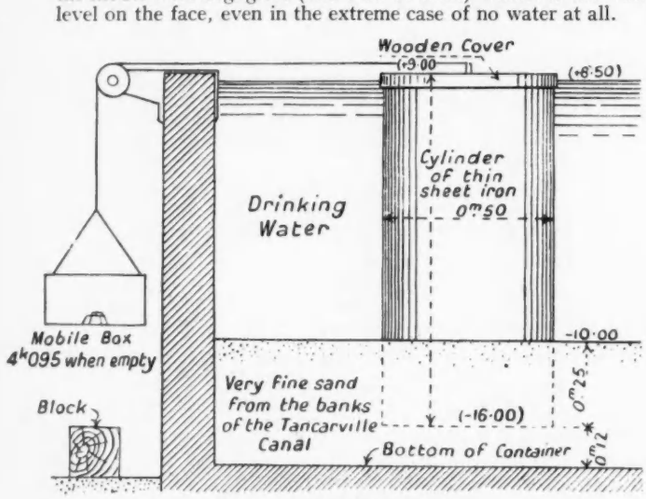


Fig. 6. Scale Model of Dolphin

When it was attempted to increase the surcharge, a settlement of sand occurring in the filling caused the front two rows of blocks to fall and thus partly destroyed the model. The settlement appeared to be due to the model sliding forward under pressure of the surcharge and showed the limit of loading to be 70 tons per sq. m. of the actual quay. In this there is a large factor of safety, compensating for the allowance which should be made on account of the sand in the model having too high an angle of internal friction.

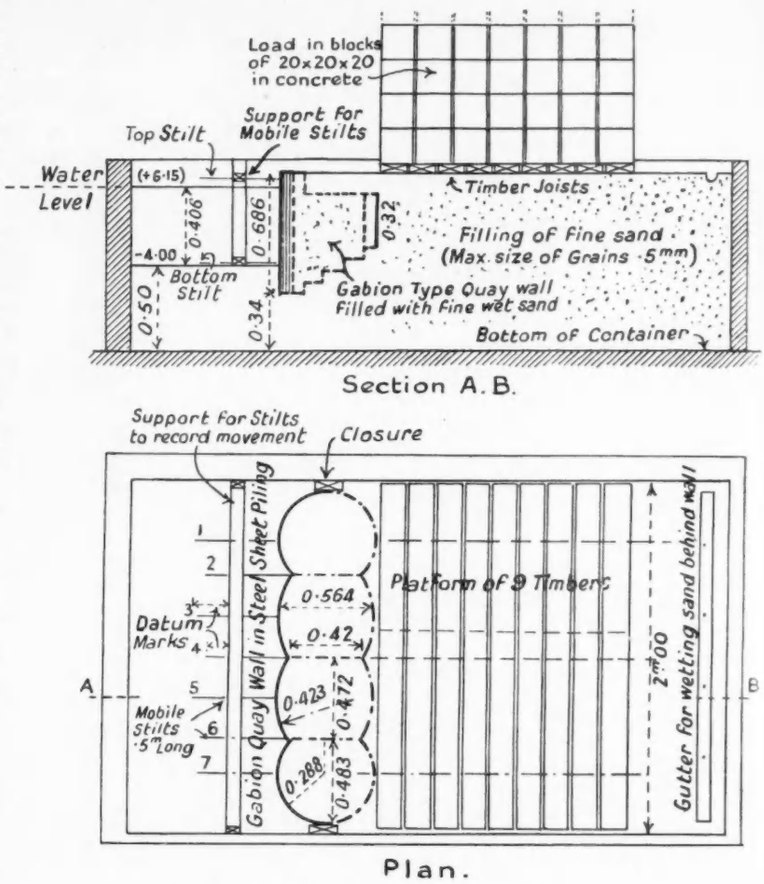


Fig. 7. Scale Model of Gabion Quay Wall

In concluding this note, an acknowledgment must be made to M. Mallo, Director of the Port Laboratory, who carried out the experiments described, with such great ingenuity, care and precision.

Singapore Harbour

Excerpts from the Annual Report of the Harbour Board for the Year ended 30th Jnne, 1938

After providing for Interest and Sinking Fund Contributions in the sum of $1,603,365.35 the Income and Expenditure Account shows a surplus of $2,364,557.61 as compared with a surplus of $479,479.92 last year. Of the total expenditure for the year amounting to $7,461,540.09 the amount of $1,867,372.41 or 25% is uncontrollable by the Board, being Interest and Sinking Fund Contributions, Municipal Assessment and Audit Fees.

The number and total net registered tonnage of vessels berthed at the wharves during 1938 was 3,231 vessels, totalling 9,756,410 tons, compared with 3,242 vessels and 7,708,417 tons for the year 1937.

The trade handled at the wharves during the year was, in the aggregate, 3,384,003 tons or 8% more than that for the previous year. General cargo inward increased by 84,569 tons or 6%, whilst general cargo outward increased by 99,251 tons or 9%. Coal inward increased by 39,512 tons or 17%, whilst coal outward decreased by 2,350 tons or 1%. Fuel oil inward increased by 16,097 tons or 16%, and fuel oil outward increased by 5,488 tons or 6%.

The mechanical coal handling plant is in course of erection and, it is anticipated, will be completed early in 1939. The shore bunkering installation and floating bunkering unit are being manufactured and will also be ready for use in 1939.

Plans for the reconstruction of the East Wharf are completed and the work will be commenced early in 1939.

The West Wharf Extension (Schemes " C " and " D ") was practically completed during the year and was formerly opened by His Excellency the Governor, Sir T. S. W. Thomas, G.C.M.G., O.B.E., on the 28th July, 1938.

The question of providing additional dry dock and wharfage accommodation at Keppel Harbour is still receiving consideration. The wooden wharf east of the King's Dock entrance is being replaced by a reinforced concrete wharf.

The Maintenance of Depths alongside Wharves by Dredging

By HERBERT CHATLEY, D.Sc. (Eng.), M.Inst.C.E.

IN practically all harbours there is a certain amount of accretion under and alongside a wharf which, in course of time, reduces the available depth of water. In some places, such accretion is so large as to necessitate almost continuous curative treatment, and may even render the wharf useless or uneconomic.

Stability of Berth Bottoms

In a river harbour where silting is prevalent and wharves are situated along the banks, the artificially created depths alongside are frequently greater than are consistent with the natural régime and there is a steady tendency to revert to the previous conditions. This may be aggravated by natural or artificial deepening of the main channel which tends to increase the mid-stream velocity and so, since the mean velocity remains practically the same, the longshore velocities are diminished and silting is accelerated. The hydraulic resistance of open piling also checks the marginal velocity. Material accumulates under the deck and gradually slips down into the berthing space. If the substructure of the wharf is closed there is a tendency for a slope to be built against the face of the wharf. In straight reaches there is a slight helical current, which runs obliquely on the surface of a river towards the centre, descends there to the bed, travels obliquely outwards across the bed and ascends the sides. Since the latter motion is opposed to gravity, silt tends to be transferred from the centre of the channel to the shores.

On concave shores the stability conditions are much better, but the greatest velocities occur some little distance from the shore, and by causing bottom scour may cause the surface and bank material to slip on to the berthing space, in spite of increased depths appearing further out. This condition, incidentally, may endanger the stability of the wharf as a whole.

On a convex bank the longshore velocities are low or may even be backward relative to the main stream. There is, moreover, a special spiral current at bends which ascends the convex shore. From both causes, such convexes accrete more rapidly than other parts of a river bed.

In a marine basin or a cul-de-sac, silting is more or less uniform, depending simply on the degree to which the water is changed, which again is principally dependent on the rise and fall outside, i.e., the tide. Thus, if the mean tidal range is, say 7-ft. and the mean silt content is 100 parts of solids per million by volume, as there are about 700 tides per annum, the mean deposit will be $(7 \times 700)/10{,}000 = \text{say, } \frac{1}{2}$-ft. per annum of solids, which will bulk with contained water to a thickness of from 1-ft. to perhaps 3-ft., according to the fineness and irregularity of the particles.

Abruptly ended excavations in river convexes may silt up with very great rapidity, owing to bottom drift and the silt falling from the continuously passing stream above them.

By courtesy of] Dredger, working a 1 cu. yd. Grab at 18-ft. radius, in Japan [Priestman Bros.

General Principles of Riparian Dredging

Having regard to these circumstances, the following conditions may be indicated in connection with dredging alongside banks or wharves.

(1) The new depths should depart as little as possible from the known régime conditions.
(2) The cut should extend outwards and endwards into equal or greater depths, so that such current as there may be can flow over it, or if a trench is made it should run out at its ends into water of equal or greater depth.
(3) The cut should be made as quickly as possible and only present abrupt changes of depth for a very short time.
(4) Large shallow cuts are more stable than short deep ones.
(5) If the volume to be excavated to produce a horizontal or sloping shelf out to water already of the desired depth is very large, it is expedient to cut a through trench parallel to and near the shore extending to the deep water at its ends and subsequently to widen it, rather than to attempt cutting the whole width at one time.

Types of Dredger

In the excavation of bed material alongside a wharf, a dredger needs to fulfil most, if not all, of the following requirements:—

(a) Rapid working, so as to minimize re-accretion and reduce the time in which berths are out of use.
(b) Minimum mooring space, to avoid interference with traffic and use of adjacent berths.
(c) Easy removal to and from site.

Maintenance of Depths alongside Wharves by Dredging—continued

(d) Ability to work close up to vertical face.
(e) Accurate depth and position control, so as to avoid over-dredging and irregular cutting.
(f) Level cutting of the bottom.
(g) Simple expeditious arrangements for removing spoil.

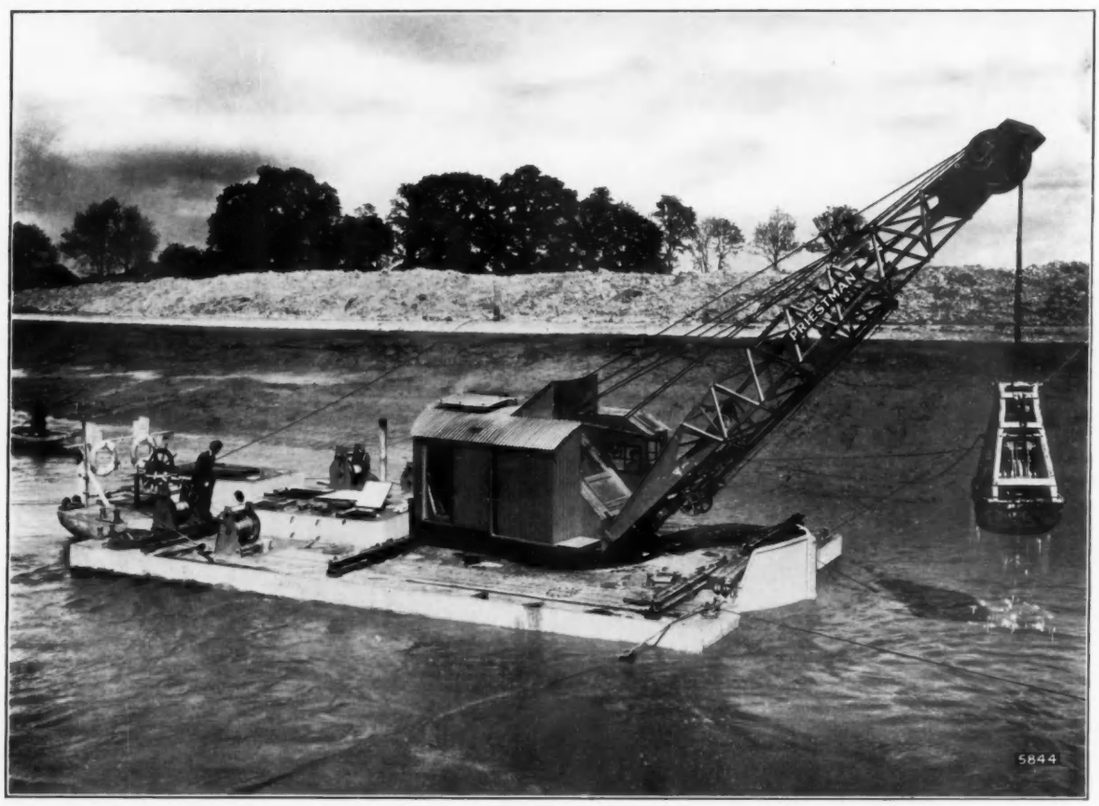
Some of these conditions conflict with one another and compel a certain amount of compromise. Thus rapid working implies a large dredger, whereas the reduction of interference with shipping favours a small one. Level cutting and accurate depth and bottom control favour the ladder-bucket type, but this type is not satisfactory unless it is fairly large and can only work up against a vertical face if it has a side ladder or is set square to the wharf face. It is also more likely to injure the wharf if used close up. Spuds are preferable to anchor moorings, but are more expensive to instal. Dipper dredgers are less economical than grabs, except in heavy firm material, and the hulls are larger. They also cannot cut to the full depth quite close up to the face of the wharf. Suction types are rarely satisfactory for wharf dredging, unless the material is coarse, loose sand, which is rarely the case with re-accretion. Working in clays, a rotary cutter is necessary, and this cannot be brought close to the wharf face, and the spoil contains a large amount of water which cannot be easily separated from the spoil. Unless great care is taken, the suction dredger of the moored type makes an uneven cut. Unless traffic conditions will allow of a pipe-line to an adjacent shore basin or dumping pool, the suction type of dredger is usually out of the question.

Except in hard bottoms, the usual practice is to employ grab dredgers with attendant barges. The cycle of operations (cut, lift, swing, drop in barge and swing back) occupies usually less than one minute, so that the full dredging rate is about, say, 70 times the mean effective bucket load per hour.* The mean dredging rate is reduced from this by the time required to change barges, waiting for empty barges, breakdowns, interference by ship traffic and shifting the dredger moorings, so that in the long run it is rarely possible to achieve much more than 50 bucket loads per hour.

Size of Dredger

In those cases where accretion is small, it may prove economical for a wharf owner with a moderately long frontage to keep a small grab dredger (say, ½-yard bucket) working continuously, but for steady work small grab dredgers are less efficient than large ones; the delays in changing barges and shifting the dredger are nearly as great as those with larger vessels and reduce the mean output to a very small figure. The smaller weight and closing power of the small buckets causes them to make much less satisfactory cuts and the work is more likely to be hampered by stones and other obstructions. On the other hand, very large grab dredgers are objectionable on account of the space occupied by the hull and moorings and the great weight of the individual bucket load, which compels the use of very strong barges.

In general, it is found that a 1½ cu. yd. bucket capacity is convenient, allowing a mean output (including normal delays) of, say, 75 cu. yds. per hour, which is fairly satisfactory. The hull of such a vessel may be about 80-ft. long and in, say, 30-ft. of water the six moorings will extend some 200-ft. above, below and sidewards from it, when in the middle position. If the barges have a capacity of 300 cu. yds., they will take three hours to fill (at the 70 cycles rate), and unless the distance to the disposal point is large, or the time of emptying prolonged, two such barges and one tow-boat will suffice.



By courtesy of] **A Grab Dredger, with jib in two sections for working at radii of 25-ft. and 50-ft.** [Priestman Bros.

Moorings

The large space required for mooring the usual type of dredger is a serious objection in wharf dredging. The fore and aft lines and anchors are apt to foul adjacent berths and the lines may become entangled with those of berthed ships. They obstruct the access to the wharf of boats and lighters and require appreciable time to shift when the dredger can no longer work within them. The anchors themselves are dangerous to ships, and must be marked with buoys. At the wharf side the dredger may be attached to bollards or other parts of the wharf, but the gradual swing of these shore lines may be inconvenient, and in the case of old wharves an undue strain may be put upon the structure. All these difficulties are reduced with spuds, which are vertical (or slightly inclined) columns which are housed into the hull of the dredger and sink into the river bed, and can be raised at will by winches on the dredger. On the other hand, the spuds are subject to very great bending moments, and must therefore be very strongly built. They are, therefore, expensive and heavy to manipulate and increase the size of the hull. To be effective they must penetrate well into the bottom, which is a difficult matter if the bottom is hard or very soft. With a grab dredger, side moorings are still required to enable the dredger to be moved, but with a dipper dredger the dipper itself may be used to swing the vessel about one spud (the others being raised) so that the position may be gradually changed. This involves, however, a slight delay at each shift, whereas with moorings, the winch control can operate without delay until the moorings have to be moved and the dredger can be pulled up against the face of the cut.

* Rates up to 120 cycles per hour are possible, but only occur with favourable materials, to which the plant happens to be just suited, and great skill and energy on the part of the operator.

Maintenance of Depths alongside Wharves by Dredging—continued

Over depth Dredging

In order to obtain a clear specified draught alongside, dredging must be done to a somewhat greater depth, because no type of dredger gives perfect control of the depth of the cut and some ridges or humps are bound to be left, especially with the grab type of dredger. This is a source of trouble, since it involves a larger volume of excavation, may increase subsequent re-accretion, and in some cases affects the stability of the wharf. Practiced dredger-masters can achieve very good results, but it should always be reckoned that the actual depth dredged will vary from nothing to perhaps 2 or 3-ft. below the prescribed level.

Measurement of Dredging

Whether the work be done for a lump sum or at an agreed unit price, either the contractor or the owner is interested in knowing how the actual volume removed compares with the previously estimated quantities and the barge measurements. It goes without saying that a careful survey should be made beforehand, but the estimates are never quite correct because of accretion or scour in the interim, errors in allowance for tide levels, softness of the bottom, swing of the sounding lines, etc. The quantity of material in the barges, if taken by the space occupied in the barge, is greater than the situ space occupied by the material on account of the water brought up and the interstices between the lumps. The surface of the material is also not level in the barge. If measured by weight (from the increased displacement of the barge), there is still an error due to the water brought up with the material. Measurements of the bed taken after dredging are again liable to the same errors as those taken before, plus the difficulty of an irregular bottom. In these circumstances, no real accuracy is possible. The practice with which the writer is familiar is to charge by the barge measure, in which it is assumed (on the basis of past measurements) that the material has expanded 40 per cent. in excavation and by reason of water brought up. With very soft material, this is an over estimate of the expansion, but with hard material it may be too small. Soundings before, a rough estimate of quantities and soundings after dredging are supplied and the wharf owner can, of course, check all or any of these measurements.

By courtesy of] Riparian Dredging with Dipper Dredger [Lobnitz & Co., Ltd.

Slipping from under Wharf Decks

In the case of open wharves, accretion occurs under the deck, and when the back of the wharf is closed a slope is built up there, which tends to slip away when the front is dredged. This is an objectionable matter, because the slip may not occur until some time later, when it may annul part of the improvement. It can only be accelerated by over-dredging in front (which may be dangerous for the wharf) or by attacking the slope directly with digging tools or jets. The quantity of slip must be included in the estimates.

Disposal of the Spoil

It cannot be too strongly emphasised that the problem in dredging is not so much in the excavation as in the disposal of the material. In the majority of cases, it cannot be dumped into the water within a short distance from the site. Either it must be transported to a large distance, or it must be put ashore. Even the latter is frequently only possible at an appreciable distance. In either case, the spoil must be carried in a hopper barge (or in a hopper on the vessel itself).

Economics of Wharf Dredging

The cost of dredging depends principally on the nature of the material, the size and output of the dredger, the length of transport of the spoil and the facilities for disposing of the dredged material. Other factors that enter into the problem are the distance from which the dredger has to be brought, and the degree to which the normal business of the wharf is interfered with. If the wharf is one at which every berth is normally occupied and a definite loss of wharf rent is involved, two alternatives present themselves. Either a very rapid dredging with comparatively large and efficient plant may be employed, one or more berths being out of use, or a small mobile dredger can be employed which takes the opportunity of working during the short intervals between the departures and arrivals of ships and operates outside the ships when they are berthed. Spud moorings are rather useful in the latter case, but are not very practical with small dredgers, and tow-boat service will also be required for the longer shifts. Furthermore, in this case, the excavation is likely to be very irregular and, if accretion is rapid, the results may be very unsatisfactory, and, owing to the large proportion of lost time and the comparative inefficiency of a small dredger, the unit cost will be high. This method can, therefore, only be recommended where accretion is small.

In the first alternative, it is essential that the dredger shall be in good condition and be supplied with ample barge and tow-boat service, and a time table for the job must be worked out as accurately as the conditions will permit. If the income from the wharf is, say, 2s. per foot per day (for berthage charges only), and the dredger occupies (including moorings and manœuvring space), say, 500-ft. of wharf, there is a loss of rental of, say, £50 per day. If the quantity to be dredged is, say, 24,000 cu. yds. and the unit price is, say, 1s. 8d. per cu. yd., the total cost of the dredging is £2,000 + (£50 × days occupied).

Thus, if the plant has a daily output of 1,000 cu. yds., the total cost is £3,200. With a daily output of only 500 cu. yds., the cost is increased to £4,400. With a daily output of 1,200 cu. yds., the cost is reduced to £3,000, which may be compared with that of a small mobile plant in which the unit price was increased (on account of lost time) to, say, 2s. 6d. per cu. yd. (with no lost rent), the total cost being again £3,000.

These figures are merely indicative of the principles, and no particular importance should be attached to them, as local conditions vary enormously. With still larger dredgers the total cost rises on account of the greater frontage required. Speaking generally, wharf owners prefer to put only one berth out of action, and this will limit the size of the dredging plant accordingly.

Some extra expense may also be incurred on the wharf by reason of greater haul of cargo to the warehouses, but as this is always a varying expense, this particular difference may often be disregarded.

Overtime and Night Working

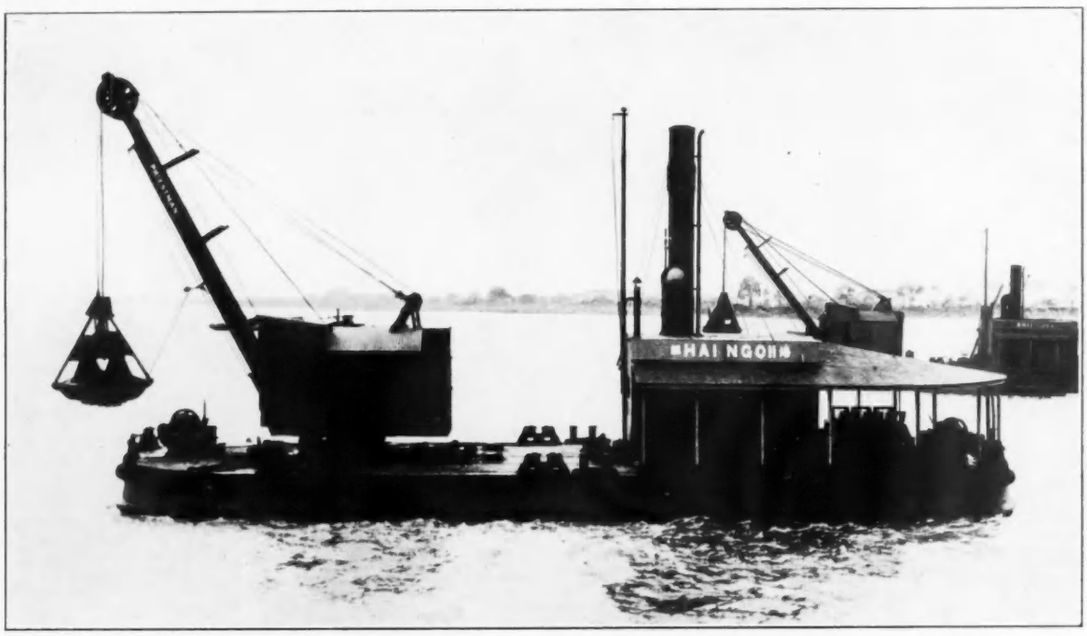
In view of the great importance of rapidity, wharf owners often desire that riparian dredging shall be carried on continuously. This is not so simple as it seems, and will generally involve an increase in the unit price. If the mud disposal is done on a large scale, serving many jobs, and the other jobs are not continuously operated, a large mud disposal unit may require to be operated to serve a small input. The rapid manœuvring of barges, tow-boats and the dredger itself at night, is appreciably more hazardous than in the day. Special accommodation for extra crews will be involved. Night shifts may require higher pay. Extra expenses are involved in flood-lighting, signal lamps, etc., and the opportunities for running repairs are lacking.

Breakdowns

Owing to the great variations in inertial and induced stress on the various parts, dredging plant is very subject to sudden

Maintenance of Depths alongside Wharves by Dredging—continued

breakages. Builders of dredging plant will assure one that this is not the case, but it most certainly is. The design of a dredger is a compromise between the demand for strength, which involves mass, and the need for lightness, which implies weakness. Doubtless, the dredgers of the remote future will be made of duralumin! British types tend to err on the heavy side and break under inertial forces. Dutch and German types tend to err on the light side and break under mechanically induced forces. Consequently, ample supplies of spare parts and the best possible facilities for repair must be available, and it will occasionally happen that the progress of an important riparian job is suddenly interrupted. Whereas the contractor will doubtless have allowed for the cost of repairs, the real difficulty is the inconvenience and expense to which the wharf owner is put by the delay. The contract should make provision for this, and some form of insurance is really advisable, although the writer has not heard of this having been used. Welding is now extensively used for dredger repairs. The very best lubricants and ropes should be used.



By courtesy of] **Two Grab Dredgers specially constructed for dredging in Shanghai Harbour** [Priestman Bros.

Private and Public Dredging Service

The writer's experience has principally been with dredging carried out by a public authority at fixed rates, which are somewhat below actual cost because of the indirect benefit to the harbour caused by riparian dredging, but there are several aspects of the question of public versus private dredging contractors. The public authority often has the advantage of possessing a large and varied plant, much better facilities for mud disposal, and may reasonably expect an average demand which will equalise costs and distribute overheads. On the other hand, unless the officials are really public spirited, acquainted with business and have been given considerable discretionary powers, private wharf owners may be treated arbitrarily and suffer losses which they might avoid in dealing with a private contractor.

The latter, on the other hand, unless he is in a very big way of business, has a limited plant of limited applicability, may find difficulty in securing mud disposal sites, and often has to bring his plant great distances to and from the job. Speaking generally, and quite apart from large contracts for new works, the dredging contractor is not very well placed to do ordinary riparian dredging, and in those cases where he is in competition with public authorities he is not usually able to offer such good terms or to do the job so well. There must, however, be many exceptions to this rather broad statement.

Special Cases

In special cases where, say, deepening in hard material is combined with the removal of accretion, rock breakers may be required. Blasting near wharves is rarely expedient. In some localities high-pressure jets, applied close to a mud surface will allow the material to be washed into deeper water. A plant for this purpose should be so designed that the kinetic energy of the jets is not much less than 50 per cent. of the horse power of the motors operating the pump, and the nozzles must be controllable so that they can touch the material to be removed. Even a few inches of space between the nozzle and the material causes practically all the momentum and energy of the jet to be transferred to the surrounding water. As for playing on the mud like a fire hose from some distance, this is practically useless. With close jetting on alluvial material an output of perhaps 1 cu. yd. per horse power hour is possible. This will be shifted to a distance depending on the fineness of the material and the local currents. In some cases two or three shifts may be necessary to get the material into sufficiently deep water. With suitably designed apparatus, this method is a good one for removal of accretion from under a wharf deck out to the front where it may be dredged in the ordinary way. The jet pipes must be clamped to something firm, as the reaction of a jet sufficient to produce useful erosion is too great for a man to be able to hold the pipe.

Institute of Transport Premiums

The Institute of Transport draw attention to the following particulars of Water Transport Premiums which will be available for award by the Council of the Institute during the current session, 1938-39. Further information can be obtained from the Secretary of the Institute, 15, Savoy Street, London, W.C.2.

Contributions are invited in competition for the two undermentioned Premiums donated by The Dock and Harbour Authorities Association. The Premiums take the form of:—

A Gold Medal for award to the author of the paper on a dock, harbour or conservancy subject, adjudged first in order of merit of those submitted for consideration.

A Silver Medal for award to the writer of the essay on a dock, harbour or conservancy subject, adjudged first in order of merit.

Contributions are also invited in competition for the Inland Water Transport Medal donated by The Canal Association.

The medal, which will be in gold, will be awarded to the writer of the paper on a subject relating to inland water transport, adjudged first in order of merit.

Finally, contributions are invited in competition for a Coastwise Shipping Medal donated by Sir Alfred Read, Past President of the Institute. This medal, which will be in silver, will be awarded to the writer (who need not be a member of the Institute) of the contribution on a subject connected with coastwise shipping, adjudged first in order of merit.

Obituary

General regret will be felt at the announcement of the sudden death of Mr. Frank Brown, M.Inst.T., the Assistant General Manager of the Port of Bristol. Mr. Brown, who was 56 years of age, was formerly assistant chief docks manager of the Great Western Railway Co. After five years' service on the staff on the London and North Western Railway Co. at Euston, he went to Newport, and became chief assistant to the general manager of the Alexandra Docks. In 1922 he was appointed assistant to the chief docks manager of the G.W.R., and was promoted assistant chief docks manager in 1926. For many years he took a leading part in ambulance work, and in 1933 he was appointed as a serving brother of the Order of the Hospital of St. John of Jerusalem. He was appointed Assistant General Manager of the Bristol Docks in 1929.

Transporting the Grain Harvests of the World

By CECIL BENTHAM, M.Inst.C.E., M.I.Mech.E., M.InstT.*

Discharging Grain by Chinese Coolie Labour

SECTION I

Introduction

IN this Lecture an effort has been made to deal with the very broad aspect of transporting the grain harvests of the world and to present the picture in such a way as to be of value to all who are interested in transport problems.

There are some two thousand millions of people on this planet who have to be fed, and for a large proportion of the world's population bread is a staple food. The cultivation of wheat has been described as "an industry as old as civilisation," and there is no doubt that the story of its evolution has been, and will continue to be, closely associated with the progress and welfare of mankind. The production and distribution of the grain harvests of the world is therefore a matter of universal interest, and one with which virtually every form of transport by land and water comes into contact.

Economic Nationalism

It is remarkable that a spirit of economic nationalism should have arisen at a time when transport facilities give such wonderful opportunities for international co-operation. The natural hazards of failures of crops from various causes are being further complicated by the introduction of tariff walls, discriminatory regulations, etc. The efforts now being made by some countries to render themselves self-supporting may be justified as a temporary expedient for the relief of unemployment and to meet political emergencies, but it is a policy that deprives the community of the ample resources of nature, which have been made available through the medium of transport.

How long Continental Europe will deny itself the grain it imported freely prior to 1914 it is impossible to say, but it is evident that whilst the rigid economic control which exists in various European countries continues the resources of the world will not be used to the best advantage.

Utilising the World's Grain Resources

If transport and storage possibilities can be fully utilised then the population could always be fully fed. There would be great advantage in freer interchange of wheat not only from the point of view of quantity but also from the point of view of quality. For example, the hard wheats grown in such countries as Canada are of great utility when mixed with the soft wheats grown in other countries to obtain the most suitable blend for milling and the best quality of bread.

Geographical conditions have imposed upon Great Britain the necessity of importing wheat because she is unable to produce it in sufficient quantities for her needs; moreover, the home-grown product cannot compete in all respects with wheat imported from other countries. On the other hand, Canada, Australia, the Argentine (and until recently the United States), export large quantities of wheat annually to Great Britain and other European countries.

It is accustomary to refer to the four chief exporters as Canada, U.S.A., Argentina and Australia. Canada receives most of the limelight because its transport has largely developed for exporting purposes, and the quality of its wheat is unsurpassed. In addition, Canada has a very advanced system of grading of wheat, which is a model for other countries to follow.

In recent years the home market for wheat has expanded in the United States to such an extent as to leave little surplus for export. This change may lead to the United States becoming importers rather than exporters of grain. At one time India shipped up to one million tons of grain each year to Great Britain, but now only relatively small quantities are sent.

The Harvest Calendar

The grain harvest calendars are fairly well defined.

Wheat is the most important of the grain crops, and its cultivation is spread very widely over the surface of the world. This ensures a continual supply which is of great importance to the British Isles, and simplifies the overseas transport by creating a more uniform factor for shipping and other transport services.

The following is an extract from Economic Studies of the McGill University:—

"The cultivation of wheat is simple, and its adaptability to various soils and climatic conditions is superior to that of any other plant, so that to-day it is grown all over the world, from the Equator to beyond the Arctic Circle, the only places where it is not cultivated being the low-lying regions of the Tropics.

"The wheat crop is harvested in one country or another all the year round, as shown in the following table:—

January	...	Australia, New Zealand, Argentina, Chili.
February	...	India.
March	...	India, Upper Egypt.
April	...	India, Persia, Asia Minor, Lower Egypt, Mexico, Cuba.
May	...	Japan, China, Central Asia, Morocco, Algeria, Tunis, Texas.
June	...	South France, Spain, Italy, Greece, Turkey, Japan, United States south of 40°.

*Abridgment of Lecture delivered to the Institute of Transport in London on October 18th, 1938. Reproduced from the Journal of the Institute by kind permission of the Council.

Transporting the Grain Harvests of the World—continued

July	... France, Germany, Austria, Hungary, Roumania, Bulgaria, South Russia, Northern United States.
August	... England, Northern France, Belgium, Holland, Central Russia, Canada, United States.
September	... Scotland, Sweden, Norway, Canada.
October	... Northern Russia, Finland.
November	... South Africa, Argentina, Peru.
December	... Burma, Australia, Argentina.

"The great wheat fields of the world lie in the temperate regions between parallels of 30°-60° N. and 27°-40° S. In Europe wheat is ripened as far north as 69° 28 N. on the Lyngenfjord in West Norway, and in European Russia it is cultivated around Archangel in latitude 64° 33 N. Spring wheats mature in Alaska up to 60° N., and in Canada ripe grain has been produced up to 65° N. on the Mackenzie River. Wheat also has a wide altitudinal range; in Mexico, Colombia, Equador and Abyssinia, cultivation is carried on at 8,000 to 10,000-ft. elevation.

"The countries producing the greatest amounts of the best wheats are those which have a cold winter and a comparatively hot summer. For the most satisfactory growth and development of the grain, a cool moist growing season followed by a bright, dry and warm ripening period of six or eight weeks with a mean temperature of 66° F. is necessary. An annual rainfall of 20 to 30 inches is sufficient if the greater part of it falls during the growing season."

From the foregoing it will be seen that the centres of production month by month are well known, and the quantities usually produced and exported are fairly accurately estimated each year. The quantities moving into ports of distribution or reception are on record, so it is possible to estimate the primary and the secondary sources of wheat supply for particular countries.

Grain Production and Distribution

The introduction here of some statistics of production for wheat and other grains will reveal in some measure the problem of distribution. The following table shows the average annual harvests in eight principal grain-producing countries:—

Annual Production in 1000's of Tons (English Tons of 2240 lb.) based on Average for period 1931-36

Country	Wheat	Maize	Barley	Oats	Rye	Total for each country	Percentage of world total grain production
1. U.S.A.	17,800	54,700	4,300	13,300	800	90,900	22.7
2. Russia	25,500	4,000	6,600	14,800	20,500	71,400	17.9
3. China	22,200	6,700	7,800	—	—	36,700	9.2
4. Germany	4,700	—	3,300	5,800	7,600	21,400	5.3
5. Argentina	6,100	8,700	600	800	—	16,200	4.0
6. Canada	8,000	—	1,600	5,100	—	14,700	3.7
7. India	9,400	2,100	2,400	—	—	13,900	3.5
8. France	8,100	—	1,000	4,600	—	13,700	3.4
Total for each type of grain ...	101,800	76,200	27,600	44,400	28,900	278,900	69.7
World total	145,000	103,000	45,800	61,300	44,300	399,600	100
Percentage of world total	70	74	60	72	65	69	

This percentage indicates the proportion contributed to the world's total by the eight principal producing countries. Where no figures are shewn the amounts produced are small or (in the case of China) no reliable figures are available.

Rice is excluded from these figures because it is not usually considered one of the grains—although there is no good reason for this. Seeds, such as linseed and soya beans, are also excluded, though the quantity grown and transported is large. Records of seed production are not readily available.

It will be seen that the total world production of wheat, maize, barley, oats and rye amounts to some 400 million tons annually, all of which has to be transported to the consumer who may be situated in industrial districts remote from the harvest fields, or in a foreign country.

Approximately 370 million tons of grain are consumed in the country of origin or in adjacent countries available by road, rail or water transport.

An average quantity of about 30 million tons of grain is transported annually across the ocean from one continent to another. It will be observed that this amount is only 7½ per cent. of the total production, and although there is a tendency for this exportable percentage to receive major attention in Great Britain, it is unwise to lose sight of the fact that practically all grain is transported some distance in the country of origin—in some cases over thousands of miles.

An astonishing feature brought out by a study of the problem is the uniformity of the world yearly production of all grains, particularly wheat. Five per cent. up or down represents the fluctuations in the production of wheat over six years. The overseas transport shows a much wider percentage of fluctuation than the total world production. The total overseas fluctuations for all grains amount to 33 per cent. for the six years 1931-36. Some of these fluctuations have been caused by human efforts to balance economic systems, but others are due to natural causes—failure of crops in one country or large surplus in others. Famines are now comparatively rare, but it is still found that in some countries serious shortage occurs in some years.

An outstanding fact is that the British Isles is by far the largest single importing country in everything except rye.

The total grain production of 400 million tons per annum is divided roughly as follows:—

Wheat	145 million tons
Maize	103 " "
Oats	61 " "
Barley	46 " "
Rye	45 " "
Total	400 " "

From the point of view of international trade, the principal countries may be grouped as under:—

1. Exporting countries:—
   Canada, Argentina, Australia.
2. Importing countries:—
   Gt. Britain and Eire, Belgium, Holland, France, Italy, Switzerland, Scandinavia, other European countries.
3. Grain producing countries which neither export nor import any large quantities of grain:—
   Russia, China, United States, India, Germany, etc., etc.

It is interesting to note that the great bulk of the world's grain is produced in the countries in the third group mentioned above. On account of their relatively small populations, Canada, the Argentine and Australia are able to rank as the world's greatest exporters of grain, although their actual production is less than that of many other countries. Canada, for example, with a crop representing only 5.5 per cent. of the world's total wheat production, is nevertheless able to provide nearly half the total world exports of wheat. The Argentine, with only 8.4 per cent. of the world's maize production, supplies 71 per cent. of the total world exports of maize. At the same time, all three of the great grain-exporting countries possess enormous undeveloped reserves of production. In Canada there are great areas of land still to be brought under cultivation; in Australia, irrigation schemes are steadily increasing the fertility of the land, and in the Argentine there is scope for a great increase in the grain harvest by means of improved methods of cultivation. Other countries, such as Russia, India, and the United States, have lost the prominent position they previously held as grain exporters, but there seems to be no likelihood of any decline in the supplies available from Canada, Australia and the Argentine even if their home requirements should become much greater.

In considering the movements of grain in international trade, the main sources of supply are thus well defined. The grain transport routes are nearly all directed towards Europe, and towards Great Britain in particular. As already mentioned, the actual quantity shipped is less than 10 per cent. of the world's total production, but this is, nevertheless, a formidable quantity, requiring a very extensive transport organisation for its collection, shipment, unloading, and final distribution. A general indication of the principal wheat shipment routes, and the quantities carried on each route, is shown on the Chart, Fig. 1.

Transporting the Grain Harvests of the World—continued

To simplify the diagram, each whole line represents one million tons transported, and the circles indicate the approximate quantity from each principal exporting country.

This indicates how the bulk of the wheat exports converge on the industrialised countries of Western Europe and, in particular, on Great Britain. It shows how the grain is drawn from many parts of the world, commencing in small streams and ending in a large flow into this country.

The inhabitants of the British Isles depend for their existence upon adequate supplies of grain from overseas. The regularity of the supplies ensures a good standard of living, and this standard of living has been enhanced by the power of this country to buy cheaply where there is a surplus and also to buy the quality desired.

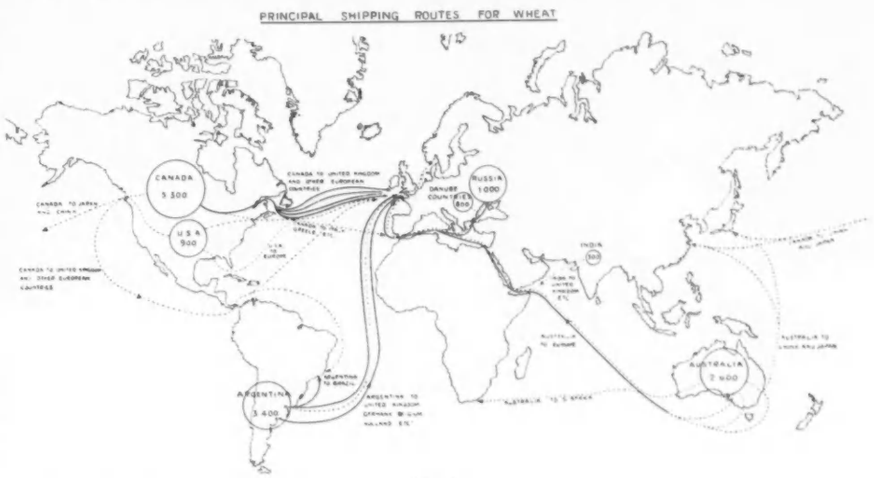


Fig. 1.

NOTE:—The figures shown in circles are the average annual wheat exports during the period 1931-36 in 1,000's of English tons of 2,240 lb. The full lines each represents one million tons and the broken lines represent quantities less than one million tons.

Three main trade routes stand out on this chart: the route from Canada via the Great Lakes and the St. Lawrence to the Atlantic and on to Europe; the Atlantic route from Argentina to Europe, and the long Red Sea and Mediterranean passage by which grain comes from India and Australia.

The traffic on these routes is seasonal, varying as each source of supply in turn becomes available. The problem of transport is thus closely linked up with the harvest seasons and the climatic conditions in the various exporting countries. In Canada, for example, very little wheat can be sown in the autumn owing to the severity of the winter. The wheat crop consists mainly of spring-sown wheat, which is harvested about August, and becomes available at the ports of shipment in the late autumn. Canadian wheat exports reach their maximum in November and December and then fall away while the Great Lakes and St. Lawrence route is icebound. During this period Argentine and Australian wheat comes on the market, and shipments from these sources are heaviest about February. Canadian wheat is again exported in large quantities when the Great Lakes' route re-opens in May, and during the summer months supplies become available from Russia, India and the Danubian countries. Partly on account of this rotation of the harvest periods and partly by virtue of the excellent storage facilities in some of the exporting countries, the overseas flow of grain is fairly steady throughout the year. The shipments from any one source are, of course, at their maximum during the months immediately following the harvest.

Having regard to these considerations of production and demand, the problem of transporting the world's grain harvests can be stated in a general manner. In the first place, it entails the collection of about 400 million tons of grain from the localities where it is grown, and its distribution to the centres of population. In cases where the producing country has an exportable surplus, there is the further problem of assembling and storing this grain at the ports of shipment, and of loading it out rapidly to ships.

When studying the problem of grain transport the relative importance of bag and bulk handling necessarily arises; although there is a world-wide tendency to change from bag to bulk, progress is slow. Approximately 300 million tons are still transported in bags, and at some stage are stored in this manner. Approximately 110 million tons are transported in bulk throughout or at some stage of transit.

Argentine—Bulk Loading to Ships

It is impossible to visualise the future relative developments of bag and bulk storage and transport, because in countries where labour is very cheap there is little incentive or desire to change. If the standard of living in these cheap-labour countries rises, if western civilisation is adopted, if grain travels along very defined tracks, and if countries interchange products freely, then moving grain in the cheapest manner for large quantities over long distances is likely to make progress.

The wheat from which our daily bread is produced is gathered from all quarters of the globe, and to trace its movements in terms of transport involves a survey of methods in use all over the world. It will be found that some countries still rely on the most primitive methods of transport; others have developed an organisation by means of which vast quantities of grain are handled rapidly and economically. Between these two extremes every intermediate stage of development is to be found.

(To be continued).

Changes in Port Personnel.

Mr. Robert A. Mitchell has resigned his seat on Belfast Harbour Board, and the vacancy has been filled by Mr. Hugh Armstrong, a member of Belfast Corporation.

Captain I. Jones, of Penarth, has been appointed Dockmaster at the Great Western Docks, Plymouth, in succession to Captain H. E. Wall, who retired on January 1st, after 35 years' service in the Marine Department of the Great Western Railway.

Captain Hans Thogersen has been appointed Harbourmaster of the Port of Copenhagen as successor to Captain H. C. Hansen, who resigned his position at the end of last month. Captain Thogersen has been connected with the port since 1923, prior to which he was first officer on board one of the vessels of the United Steamship Company. Mr. Robert Svendsen will succeed Captain Thogersen as port officer.

General View of Sharpness Docks

Electrification of Hydraulic Machinery at Sharpness Docks

The Sharpness Docks and Gloucester and Birmingham Navigation Company, in conjunction with Messrs. Vickers-Armstrongs, Ltd., have recently carried out the electrification of the whole of the hydraulic machinery of their Sharpness Dock; through the medium of electrically-driven variable stroke pumps of The Variable Speed Gear Company's manufacture.

Before proceeding to the description of this conversion, it would seem desirable to give a short description of the plant involved, the reasons which led to the decision to electrify, and the considerations which governed the choice of method which was adopted.

The hydraulic machinery at Sharpness consists of:—

(i) Twelve gate winches operating the three pairs of gates through chains. These are driven by two-cylinder hydraulic engines having double-acting oscillating cylinders.

(ii) Twelve sluices in the walls of lock and basin entrance, worked by direct-acting hydraulic cylinders.

(iii) Three 5-ton capstans, one at the lock and two at the basin entrance, all worked by three cylinder radial engines, having single-acting oscillating cylinders.

(iv) One 20-ton coal hoist, having lifting and tipping motions worked through chains by hydraulic rams and cylinders, and

(v) One 1-ton turnover capstan serving the coal hoist, worked by a 3-cylinder radial engine with single-acting oscillating cylinders.

Pressure water was supplied to these machines through cast iron pipes, from a power-house at the south side of the lock. The pumping equipment consisted of two steam-driven pumping engines of a total capacity of 210 gallons per minute at 700 lbs. per sq. in. A weight-loaded accumulator of 10-in. ram and 14-ft. stroke, is connected to the main near the power-house, and there is a similar accumulator at the end of the extension serving the coal hoist. The engines were supplied with steam by two Cornish-type boilers.

The boiler equipment and the smaller engine, and the machinery and pipes serving the lock and basin entrance were installed in 1893; the coal hoist, with extension of piping and accumulator to serve it, in 1908; and the second engine in 1913.

In 1935, it became apparent that the boilers and the smaller pumping engine had very nearly reached the end of their useful life, and that the pipe system was in the same condition. The hydraulic machinery and accumulators were, however, in good condition. The Dock Company was therefore faced with complete renewal of the boilers, one engine and the whole of the hydraulic mains.

Since at that time the Dock Company were engaged in replacing their existing gas lighting by electric lighting of an up-to-date type, and were using electric power in increasing quantities in machinery serving granaries and grain elevators, the possibility of electrifying the hydraulic machinery was investigated. It was felt that considerable economies in operation might be realised by such a conversion.

The substitution of electrically-driven pressure pumps for the existing steam plant was ruled out owing to the condition of the pressure mains which would have had to be entirely renewed. The direct electrification of all the machinery would have meant the scrapping of a large amount of plant which was in excellent condition.

With regard to the gate machines and capstans, it was desired to retain the hydraulic operation of these, owing to its many advantages, particularly safety, simplicity, ease of manipulation and maintenance, and its capacity to exert a steady force without motion for an indefinite period.

As regards the coal hoist, direct electrification would have involved the radial alteration and reconstruction of the appliance.

In view of the considerations outlined above, it was decided to carry out the electrification of the existing hydraulic machinery of gate machines, sluices, capstans, and coal hoist, through the replacement of the existing hydraulic power supply system by a number of self-contained pressure-oil systems, each supplied by an electrically-driven "VSG" Auto-Pump unit.

By reason of the lay-out of the dock, the machines fall naturally into five groups, namely:—

1.—North side of lock: Four gate machines, four sluices, one capstan (5-ton).
2.—South side of lock: Four gate machines, four sluices.
3.—North side of basin entrance: Two gate machines, two sluices, one capstan (5-ton).

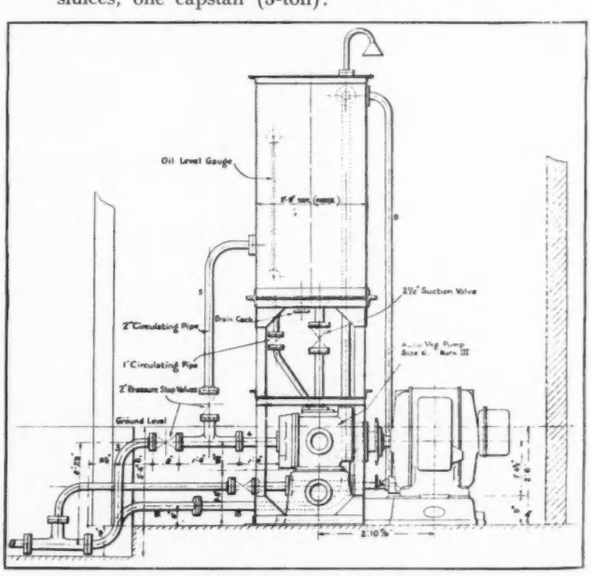


Fig. 1. Arrangement of Pumping Set

Electrification of Hydraulic Machinery at Sharpness Docks—continued

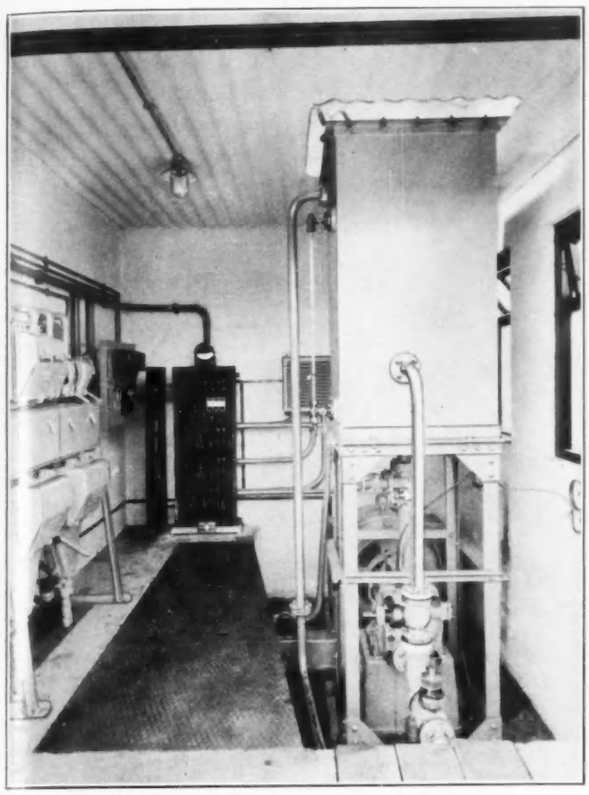


Fig. 2. Typical Pump Installation

4.—South side of basin entrance: Two gate machines, two sluices, one capstan (5-ton).

5.—Coal hoist: Lifting cylinder, tipping cylinders, one capstan (1-ton).

The machines comprising each of these groups are now connected to an independent system of pressure and return pipes laid in concrete trenches having removable covers, which replace the existing buried hydraulic pipe system.

Each pumping set is installed in a concrete pump-house, situated in a position convenient to each group of machines, and comprises a "VSG" Variable Delivery Auto-pump direct driven by a 3-phase slip-ring induction motor mounted on a common bedplate with oil supply tank, electrical switch-gear and motor starter.

The characteristic of the Auto-controlled Pump is that it gives full delivery up to a pre-determined pressure, above which the delivery decreases with increasing pressure until the maximum pressure is reached for which the control is set, when the pump stalls, that is, it runs in the " no-stroke " position with no-delivery, but holding the maximum pressure.

The oil tank is arranged with float safety devices in case of high or low level, which stops the motor and gives an audible warning. It should be noted that the oil is continuously filtered to reduce the possibility of damage to rams or piston.

The "VSG" Auto-pumps for the four basin and lock systems are size 6 Mk.III, each driven by a 45-b.h.p. motor, and for the coal hoist, size 12 Mk.III, driven by a 50 b.h.p. motor. The control gear, in the case of the lock and basin units, is of the automatic contraction type, capable of starting the motor against twice full load torque in not more than 30 seconds, and push-button controls are provided for stopping and starting these units from convenient points near the gate machines.

In the case of the coal hoist, the motor is controlled by an oil immersed hand-operated starter switch and resistances.

The method of operating the pump-sets is as follows:—

When the motor is started, assuming all control valves to be shut, the pressure in the system rises almost instantaneously to the maximum working pressure, as the automatic control returns the stroke mechanism of the pump to the zero position, in which no more oil is forced into the pipe system, but the pressure is maintained. When the control valve of any machine is opened and oil is admitted to the cylinders of the machine, the pressure in the system tends to drop. The auto-control responds to this pressure drop and moves the stroke controlling mechanism, so that the pump delivers oil into the system, the rate of delivery being determined by the valve opening and the pressure by the resistance to motion encountered by the machine. Should the machine, as sometimes happens in the case of gate machines, encounter an abnormal resistance, such as that set up by a surge of water in the lock, so great that to overcome it would require torque greater than the safe predetermined maximum, the control will cause the pump to cease delivering further oil, while maintaining the pressure, and consequently the pull on the chains, but immediately the load on the machine is reduced, the pump again delivers oil and the machine resumes its motion.

The existing working, control and stop valves are all retained, being modified to suit the changed working fluid. Isolating valves in the pressure and return mains are provided. The piston and glands of all the machines were modified to suit the change of working fluid. The gate machines run as smoothly as, and more silently than they did, on the original water system.

The conversion, which we understand is the first of its kind to be carried out, has proved extremely satisfactory in use, the operating characteristics of the gate machines being unaltered, and in the case of the sluices, definitely improved. Considerable economies have already been realised, as compared with the steam equipment.

It would appear that this system provides a simple and satisfactory solution to the problem of the electrification of dock hydraulic machinery, and of lock gate machinery in particular.

The supply of the Auto-pump units, piping and valve system was carried out by Messrs. Vickers-Armstrongs in conjunction with The Variable Speed Gear, Ltd., the installation being carried out by the Dock Company's Engineering Department, under the supervision of the contractors.

The electrical installation was of The Electrical Apparatus Company's manufacture, and was supplied and installed by Messrs. John Newth, Ltd., of Gloucester. The electric motors driving the "VSG" pumps are of Messrs. Crompton Parkinson's manufacture.

The "VSG" pump used for the plant just described has now been manufactured for many years, but its construction may not be familiar to all. We therefore reproduce a sectional drawing in Fig. 3, from which it will at once be observed that the pump is of the swashplate variety, and that the angularity of the swashplate can be varied. There are eleven pumping cylinders disposed around the cylinder block, which is itself mounted upon splines on the driving shaft. The pistons are operated by ball-ended connecting rods from the swashplate, and the latter, the connecting rods, and the cylinder block all rotate. Admission and exhaust ports are cut in a stationary plate in contact with the end of the cylinder block, and ports leading to the cylinders connect with them alternately as the cylinder block turns. The swashplate is carried in a non-rotating tiltable housing, is supported at its back by Mitchell thrust pads, and is driven through a double universal joint, as indicated on the drawing. A variable delivery characteristic is conferred on the pump by so mounting the swashplate housing that it can be moved between a position at 90 deg. to the main shaft and that shown in the drawing. For automatic operation under the control of the delivery pressure, the housing is moved by a piston under the influence of pressure oil from the delivery side admitted continuously to its cylinder. This piston acts to move the swashplate into the 90 deg. position, at which the pumping pistons will have no stroke. Its effect is balanced up to a predetermined pressure by two springs acting in the reverse manner on the swashplate cage and adjustable for compression through the medium of a bolt.

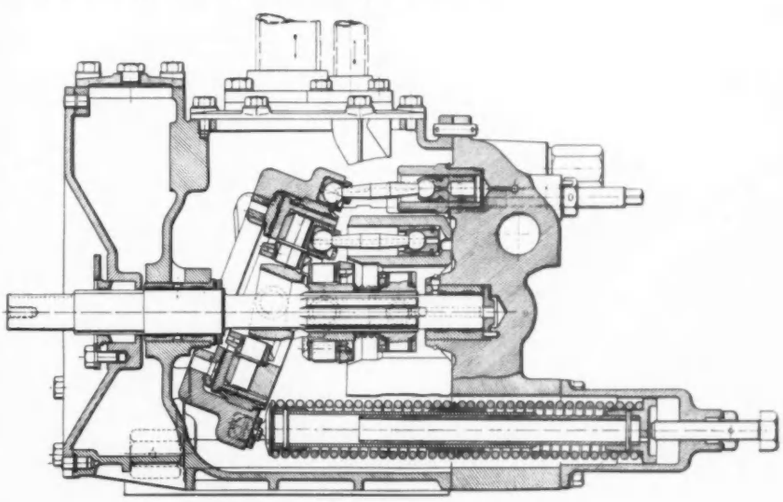


Fig. 3. Section through Variable Delivery Pump

The Humber and Humberside in Historical Times

A Survey of Estuary Development

By W. G. EAST, M.A. (Lecturer in Historical Geography at the London School of Economics)

The Humber and Humberside afford a veritable paradise for the historical geographer. It would be difficult to find in this country more striking illustration of the changes in both physical and human geography which can occur during what is, geologically, the minute span of human history. Much has already been written about these changes by historians, geologists, geographers, civil engineers and others, and many commissions, notably that on Coast Erosion (1907-09), have contributed information. Towns lost to the encroaching sea, new lands won at its expense, prehistoric forests submerged beneath deposits of alluvium, the silting of old havens, the shifting of sandbanks and the vicissitudes of Spurn Head—these are chief among the rich ingredients of which the historical geography of the Humber is compounded. A brief re-examination of this theme may be justified, if it serves only to indicate those questions which call for further investigation.

The Prehistoric Humber

The upper Humber, where it cuts transversely through the Lias and Chalk, coincides with its pre-glacial channel, which lies 60-ft. or more below the present bed. The present channel below Hull has been described as post-glacial, but the extent to which this is true has not yet been demonstrated. The breadth and form of the Humber have certainly undergone changes since the end of the last Ice Age. The more recent changes are fairly clear (see Fig. 1). What were the conditions of the Humber in prehistoric and early historical times? It is more than

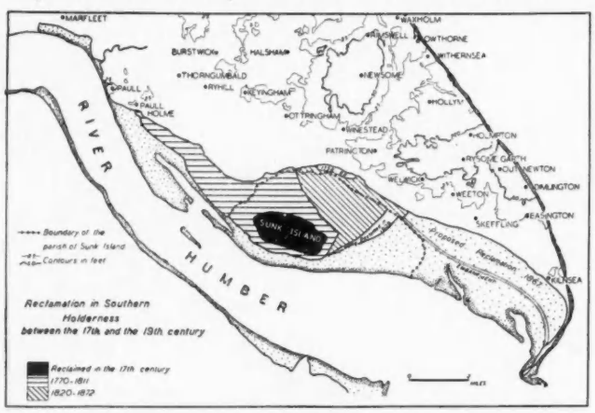


Fig. 1. Note the alignment of Settlements on the rising ground northwards of the Alluvium, the Reclamation of which began only in the 17th century. Most of the Settlements named were Anglo-Saxon Foundations, those ending in "——ing" and "——ingham" being amongst the oldest

probable that the tidal waters of the Humber once extended over the greater part of those wide areas of Holderness and Humberside which are now covered with alluvium (Fig. 2), but we cannot say just how far they extended until this alluvium has been closely studied. Another complication is that the level of the land has changed since prehistoric times. Evidence of former forests, in which men lived, lies beneath the alluvium in some places, and points to a higher land surface during the Neolithic and Bronze ages, since which this surface has subsided. The distribution of settlements during the Roman and Anglo-Saxon periods suggests the avoidance of the alluvial lands which were either under water at high tide or at least marshy. Note how Anglo-Saxon settlements, as determined by place-names, are aligned along Humberside on rising drift-covered ground, just beyond the limit of the alluvium (Fig. 1). Did these have originally waterside sites, if only at high water? In the Scandinavian† phase of settlement (late 9th and 10th Centuries) there are clear signs of settlement on the alluvial flats. Hull itself grew from the Scandinavian settlements made at this time: it has no Roman or Saxon history, for the good reason that its site was probably under water then. And there were a few Scandinavian sites which appear to have stood in south-east Holderness in the alluvium to the west of Spurn Head. These settlements—Sunthorpe, Tharlesthorpe, Ravenser, Orwithfleet, and others—were destroyed by marine inundation in the 14th Century.

* Paper read before Section E (Geography) at the British Association Meeting at Cambridge, August, 1938.

†The term Scandinavian is used here to include Dane and Norwegian.

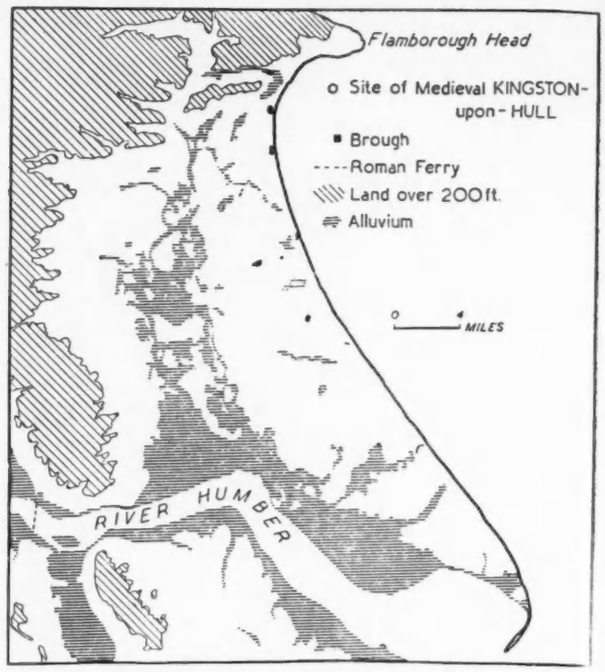


Fig. 2. The distribution of Alluvium in Holderness and Humberside. Note the site of the Roman Ferry at Brough

The Lost Towns

The exact location of the lost towns of the Humber, studied first by J. R. Boyle and more recently by T. Sheppard, is in some cases uncertain, and it is to be hoped that the study of Domesday Book (1086 A.D.) may throw more light. But it does seem clear that Scandinavian immigrants made some settlement of the low-lying lands of Humberside which were formally floodable and avoided by Anglo-Saxon colonists. Therefore it would seem that there was some narrowing of the range of the tidal Humber between the Danish phase and the great storms and inundations of the 13th and 14th Centuries. This restriction of the Humber does not call for elaborate explanation; the process of embanking may be postulated to explain it. The great storms which destroyed lands and settlements in the Humber were local aspects of a widespread phenomenon, which Pettersson has sought to explain in astronomic terms. After this period of climatic stress, there was a slow advance of the land at the expense of the sea. The reclamation of the so-called "warp" lands of the Humber between the 17th Century and the 19th is a clearly seen process, which has certainly narrowed the Humber at many points (Fig. 1). We know from a study of Greenvile Collins's famous chart (Fig. 3) and from earlier charts reproduced below as sketch-maps, how Sunk Island gradually formed where sandbanks and water formerly stood. The origin of the warp—or fine silt deposits—of which the new land was formed aroused a great controversy a generation ago. W. H. Wheeler stoutly maintained that it was not sea-borne but derived from the Humber Basin; Clement Reid and others believed that in part at least the cliff waste of Holderness was carried into, and deposited in, the Humber by tidal streams. Geologists, I

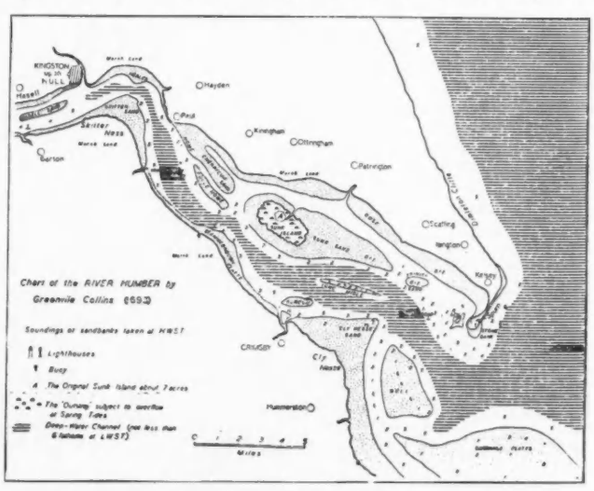


Fig. 3. Note the first stage in the reclamation of Sunk Island (marked A) the "Outstray" shown was reclaimed next. Compare with Fig. 1, showing Sunk Island Parish as it was eventually reclaimed. Note the Lights at Spurn Head

The Humber and Humberside in Historical Times—continued

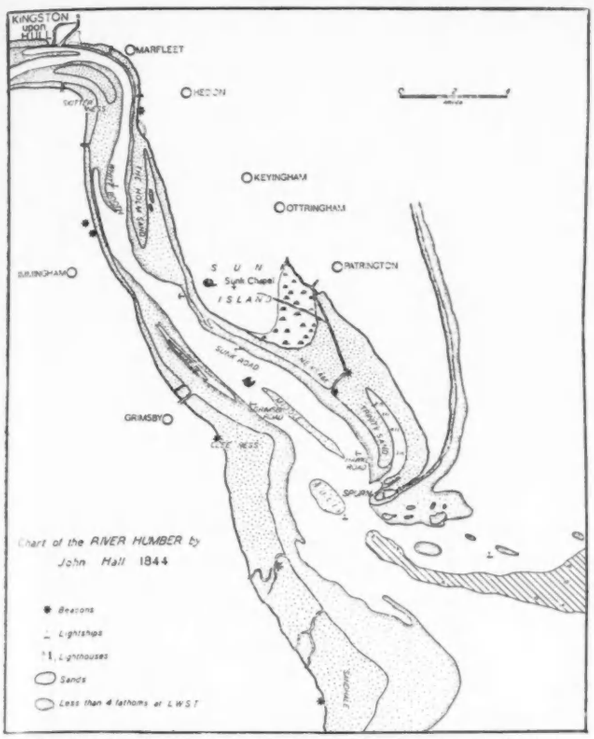


Fig. 4. The deep-water approach to the Humber is shaded, the soundings being fathoms at H.W.S.T. Within the Humber, the deep-water channels are left white. Note that Spurn Head is an island at High Water Springs

believe, thrive on scientific controversy of this kind, and for all I know, this issue may still be fresh and vital among them. I cannot discuss here the interesting process of "warping." Broadly speaking, land began to warp between the levels of neap and spring tides—i.e., samphire and other marine grasses then began to grow; the level gradually rose, the more rapidly when embanking was carried out. There was accretion, too, in the upper Humber, especially at Broomfleet and Read Island.

Early Navigational Conditions

Let us review next, in the light of old charts, the conditions of navigation in the days of sail, for the Humber was one of the great gateways of England throughout its history. The chief difficulties were extensive shoals caused by sandbanks; the rapid tidal stream and gales especially from the N.W. Depth of water in the main channels did not present difficulty, except in the upper Humber at low tides. Let us glance briefly at some of the physical factors which condition the régime of the river.

The condition of the upper Humber (i.e., above the bend at Paull) depended on the scour of fresh water from the extensive Humber Basin. There is a rapid discharge into streams within this Basin, since so much of it is elevated (the Pennines). Variations in the rainfall of the Basin, seasonally and from year to year, thus affected the scour in the upper Humber, and its condition for navigation. Therefore the channel was better in winter than in summer, and varied much from year to year, for during a 37-year period, a maximum rainfall of 45.7-in., and a minimum of 18.8-in. were recorded. Moreover, since the fresh-water was heavily charged with silt, deposits were made and many sandbanks formed. (Hence the chance of later reclamation at Read Island and elsewhere). In short, constant shifts of the channel were a danger and difficulty above Paull, and ships wisely waited for the tide to sail up. In the upper Humber there was not more than 15-ft. at Low Water Neaps, and no more than 10 or 12-ft. at L.W. Springs. In the lower river, in contrast, river water is only a small proportion of the total; the Humber is a great arm of the sea, and the outflow of the tidal waters maintained the channel. Spurn Head, though it has always varied in form, area and position—before groynes were built there in 1852 it was usually an island or islands at high water—by narrowing the mouth, helped to deepen the entry to the Humber. The river freshes did, however, affect the shoals between New Holland and Whitebooth Road. The Skitter, the most dangerous shoal in the Humber, tended to lengthen downstream; the Middle Sand, opposite Hull, was constantly changing its shape; Burcum Sand, on the other hand, stood firm and unchanging. Fig. 4 shows these shoals well.

Fig. 6. The Humber and its Approaches in Waghenaer's Mariner's Mirror, 1588. The Soundings are in fathoms at L.W.S.T.

Let us look now at a number of old charts which are re-drawn to show the deep-water channel and the disposition of sandbanks and roadsteads at different times (Figs. 5-7). Clearly these have limited value and accuracy. They seem to show that the deep-water channel of the lower Humber, between Hull and the sea, has not substantially changed since the time of Elizabeth, and that it still serves the needs of shipping at the seaports of Hull, Grimsby and Immingham, even though owing to silting, old ports, such as Hedon, are no longer accessible. In these charts the deep-water channel is shown black, and this was at least 6 fathoms at Low Water Springs (i.e., the minimum depths occurring). The Humber enjoyed the advantage of high tidal range—20-22-ft. at Hull, and more downstream.

Two of the earliest charts—the first to show soundings— both date from the 1580's and are independent of each other. (Figs. 5 and 6).

Enough has been given to indicate the elements of stability and instability in the physical setting of the Humber and Humberside, understanding of which provides a key to the successive phases of their history. Enough also to indicate that more may yet be gleaned about certain parts of the story.

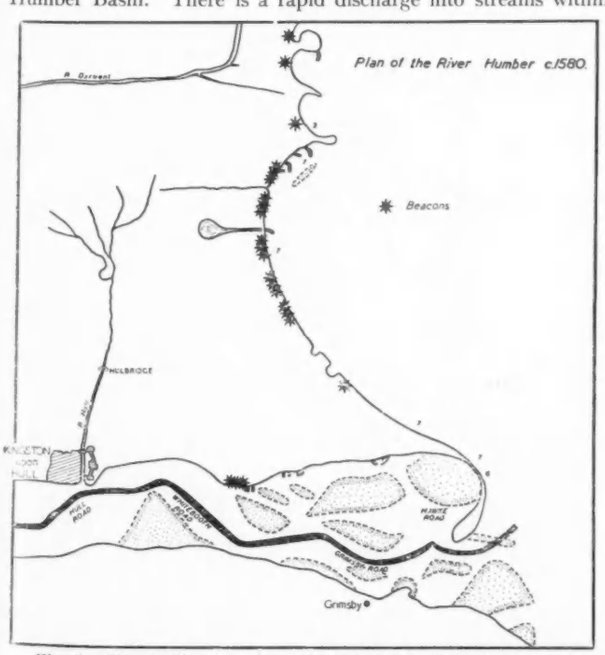


Fig. 5. Sketch Map based on the "Burleigh Chart" so-called (c.1580). The deep-water Channel is shown black. Note the roadsteads in the absence of land at Sunk Island

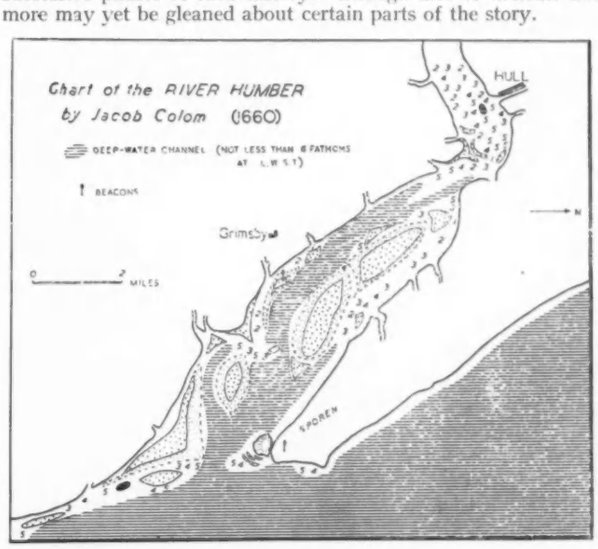


Fig. 7. The original, despite its small Scale, gives numerous Soundings

Book Reviews

Economic and Commercial Conditions in Portugal, August, 1938, by the Commercial Secretary to His Majesty's Embassy at Lisbon (published by H.M. Stationery Office, price 1s. 8d., post free).

The above Report, issued by the Department of Overseas Trade, follows a previous report dated July, 1936. In the present issue, it is stated that the progressive improvement in economic conditions proceeded steadily through 1937, when both imports and exports were substantially higher than in the previous year, but that the situation was not without its disappointments, since the wheat crop was a failure, and early in 1938, the Portuguese Government was obliged to authorise the importation of about 100,000 tons of foreign wheat, while millers were allowed to mix maize with wheat flour for bread-making.

There is some detailed notice of the trade at the ports of Lisbon, Oporto and Leixoes. In all cases the total traffic has remained much about the same as before. As regards port works at Leixoes, the construction of the new dock has been completed, but it cannot be opened to traffic until an entrance channel has been cut and dredged. This work is included in the contract for dredging the bar and harbour basin, together with the removal of certain reefs, which was awarded to a French firm for approximately £211,500. Work was begun in the summer of 1937, but little progress has been made.

The damage inflicted on the outer mole by heavy gales in 1934 and 1935 showed that the type of construction originally chosen was not strong enough, and work was suspended while other methods of construction were investigated. A solution that proved satisfactory in tank tests was found, and the work, which is in the hands of an Anglo-Dutch firm, is now being carried out. A length of about 400 metres, or rather less than half the proposed length of the mole, has been completed.

Attempts to refloat the sunken s.s. "Orania" have been abandoned, and she is now being broken up and removed by a Kiel firm at an estimated contract price of £60,000. It is hoped that the work will be finished by the end of 1938.

The report contains various statistical tables and an analysis of the principal items of imports into Portugal.

Nauticus, 1939 (22nd year). Edited by Admiral Gottfried Hansen. 513 pp. octavo. Price: 4.80 Reichsmark. With illustrations and diagrams.—Mittler & Son, Berlin, 1938.

This annual "for the marine interests of Germany" is a handsome volume. It includes 23 plates, 25 illustrations in the text, two folding maps, and a large number of tables. It deals predominantly with naval matters. The problems of naval strength and strategy, "welt-politik," and Germany's aspirations, occupy the major part of the book.

Part III (Merchant Shipping) and Part V (Industries), however, contain many matters of general interest. Part IV deals with aerial transport. There is an interesting chapter in Part III on the great ocean harbours of World Commerce, and in Part VI (Statistical) there are some useful tables as to world trade and shipping.

The chapter on Harbours is written by C. V. Krogmann, of Hamburg, and includes sections on historical development, volumes of transport in world trade, geographical questions, ranking of European ports according to tonnage of goods handled (led by Rotterdam, London, Antwerp and Hamburg), the three European Seas, the dominant points in World Trade, organisation of ports, free harbours, harbour questions, and the tendencies of future development.

It is noticeable from the statistics that Great Britain's share in world trade (by volume) has for some years been 14 per cent. and that of Germany about 9 per cent.

The book is ultra-nationalist in its viewpoint, but nevertheless should interest many readers who have not yet realised the tendencies of Germany's ambitions.

It is much to be regretted that the Gothic type of the mediæval monasteries is still being used for books such as this. The eye-strain and loss of space form blemishes on Germany's claims to high efficiency. H.C.

Report on Economic and Commercial Conditions in Canada, by A. R. Bruce.

The compilation shows that the year 1937 was a period of great industrial and commercial activity, although the recession in business in the U.S.A. towards the end caused some decline in December. The principal cause of prosperity was undoubtedly the flourishing export trade of the Dominion, the volume of which was nearly equal to that of 1929, in spite of the fact that the wheat crop last year was the smallest since 1914. The newsprint, mining and electrical power industries attained new heights in value of production in 1937, while mineral production established a new record in value of output for the third consecutive year. An analysis of the import trade by commodities with special reference to the competitive position is included, and among the other subjects dealt with are transport (water, rail, road and air), matters affecting labour and unemployment relief, wages, and immigration.

The Mysteries of Clay Structure

A Paper with the above title was given by Dr. Herbert Chatley, M.Inst.C.E., A.Inst.P., to the Junior Institution of Engineers on the 16th December, 1938.

Its main subject was the work of Terzaghi, which has formed the foundation of the practically new science of "soil-mechanics." The peculiar merit of this investigation is in having made clear the function of the water contents in granular masses, especially those known as clays. The equilibrium of clay depends on the viscosity of the water in the capillaries which resists its rapid escape and also, if the surface is "dry," on the surface tension at the mouths of the capillary passages. When the passages are very small (say one hundredth of a centimetre in diameter) the viscous resistances to flow are very large, and the surface tension at the ends of the capillaries on a dry surface is sufficient to produce important mechanical effects on the mass.

The case of a very fine grained sponge is analogous. If such a sponge be squeezed, when full of water, it will not expand when the hand pressure is removed because the surface tension takes the place of previous hand pressure, but if the sponge is placed in water it immediately recovers its original volume.

With clays, the passages are still smaller, and the surface tensions can produce tensile stress in the contained water amounting to many atmospheres. This tensile stress is accompanied by a compressive stress between the solid particles of a similar magnitude, which is called "capillary pressure." As the clay dries the volume decreases by means of this pressure until all the particles are in contact, and the water then draws into the interior, the surface at the same time changing colour.

Conversely, if a dried clay is immersed in water, the annulment of the surface tension causes the capillary pressure to force the particles apart, and the material expands and cracks. Owing to the viscosity of the water the change is gradual, and there are intermediate states in which the tension persists in the interior of a clay mass after it has disappeared near the surface.

Computed values of the surface tension and viscosity appear to show that these exceed the normal values for water when the passages are less than one hundred-thousandth of a centimetre, and Dr. Chatley put forward the view that in such minute passages the walls are covered with a film of "absorbed" quasi-solid water which effectively reduces the diameter of the passages. On this hypothesis the chemical character of the solids becomes manifest by the thickness of such a "rigid" and irremovable film, thus explaining both the effects of changing the minerals in the clay and of changing the fluid (i.e., alcohol instead of water).

These peculiarities can be quite well reconciled with recent studies of the atomic constitution of clay minerals, which have shown that, in "montmorillonite" (the clay used in ladies' "face-packs"), the water molecules can be held in sheets in the atomic lattices to an enormous extent.

The speaker went on to describe Terzaghi's "Oedometer" or consolidation apparatus which has proved a most powerful means of studying the behaviour of clays. This is simply a cylinder in which a sample is compressed between porous stones under flooded conditions (so as to eliminate surface tension), with a very delicate compressometer to indicate the changes of volume.

By studying the changes of the interstitial volume of the sample compared with the net volume of solid mineral in it (which necessarily remains practically unchanged under the comparatively small stresses involved), most interesting and useful results can be derived as to the bearing capacity of the material, the speed at which the contained water may be "expressed" and the permeability to the passage of water.

It was shown how slowly the water is forced out when the passages are very small, and how a knowledge of the conditions enables the subsidence of clay deposits and the settlement of foundations to be computed.

The importance of the ratio "epsilon," pore volume to mineral volume, was emphasised. Dr. Chatley had published data as to this in his 1922 paper to the Society of Engineers.

The effect of capillary pressure on the development of shearing strength in clay masses was next described, and it was shown how this bore on the stability of earth banks. The fact that re-moulded clays had quite a different physical structure from that of virgin material was then explained, and the magnitude of swelling pressures in re-wetted clays was stated.

The speaker concluded by indicating the practical value of the recent researches on this matter. and called attention to the records of the 1936 Conference on Soil Mechanics at Harvard.